Congestion in the MetroWest Area

Report of the MetroWest Subregional Area Study

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EXECUTIVE SUMMARY

The MetroWest area was identified by the 1997 Congestion Management Plan data-gathering program as having a large number of congested arterial roadways. Because of widespread and chronic congestion involving numerous corridors, MetroWest was nominated as a prime candidate for a subregional study. The objectives of the study were:

> **Phase I** – to update and summarize information about current transportation activities in the area, identifying data gaps, current study needs, and other congestion-related concerns of local officials; and to evaluate the potential of selected strategies to provide genuine congestion relief in the area;
>
> **Phase II** – to select several of the identified needs or problems, not currently being addressed, and carry out detailed investigation of these items.

* * * * *

The **Phase I** Report summarizes the findings of a comprehensive data-gathering and review effort in MetroWest, which included:

- A review of historic and current growth levels
- Identification of the locations of the largest current employers as well as new and pending developments
- Review and analysis of historic traffic growth based on count data; estimation of origins of MetroWest traffic at selected locations.
- Enumeration of currently-available transit services, and their limitations
- Interviews with MetroWest town planners, aimed at identifying outstanding traffic problems and potential future problems.
- Status update on pending transportation improvement projects, including TIP projects and locally- or privately-funded initiatives
- Compilation of a list of suggested study items/"next steps," based on interviews and suggestions by MetroWest Growth Management Committee members.

Key conclusions from the **Phase I** effort included the following:

- Continuing increases in population, employment and auto ownership in MetroWest communities will generate increased numbers of automobile trips and increased congestion.

- This would be true ***even if*** major investments could be made to encourage people to shift to other modes (e.g., new transit services, HOV lanes, and the like). The majority of new work trips and other new trips to this relatively low-density area will still be made by automobile.

- Most major roadways demonstrate strong traffic peaking patterns (morning and evening), reflecting the importance of commuter traffic. Additional traffic growth on these roadways is spreading to midafternoon and early evening hours. Much of this growth is probably increased ***non***commuter activity, such as shopping and personal business trips, possibly combined with the trip home from work.

- Two-lane roads (i.e., most of the north-south roads through MetroWest, and several major east-west roads) show less contrast between peak-period and off-peak volumes. They tend to carry fairly constant flows all day long.

- Most traffic on Route 9 and on other area roads appears (from model results) to be locally generated—that is, either a MetroWest origin or destination, or both.

- The combination of low-density, "campus" -style work-site developments, and increasing dispersion of employee origins, mean that densities are typically too low for successful fixed-route transit or bus service to employer sites.

- Ride-sharing initiatives, including carpooling, vanpooling, and shuttle connections to the nearby rail stations and long-distance bus stops, offer much better trip-reduction possibilities than do new transit services, for most MetroWest employer locations.

- The ***most effective methods*** for controlling congestion in this area would involve planning and land use control measures to limit growth and increase both residential and employment densities to the level where ride-sharing and limited transit begin to become effective.

- Quite a few of the congested locations identified in the 1997 CMS report are currently being addressed through projects within MassHighway or the MBTA, through local initiatives, or through studies currently ongoing at CTPS. Planned projects can ***relieve*** congested operations at many locations; however, they are unlikely to ***eliminate*** congestion caused by continued low-density growth.

* * * * *

For **Phase II**, a sub-set of CTPS work elements was selected from the list compiled in **Phase I**, and analysis on these elements was completed. The list of completed analyses includes the following items, summary memoranda for which are also included in this report:

- Patterns of commuter origins at major employer sites (Framingham's 9/90 Industrial Park—"blind" data provided by MetroWest TMA), and evaluation of potential for bus services to/from these sites.

- Intersection reconnaissance: Wellesley Street at Newton Street, Weston.
- Potential for traffic signal coordination on Route 126, Framingham.
- Alternatives for improvement at Route 9/Route 27 interchange, Natick.

Each memorandum documents the analyses conducted and conclusions reached. As time and funding permit, other elements from the **Phase I** list may be investigated as part of a future project.

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RESULTS MEMORANDA

"Tech. Memorandum #1: An Evaluation of Peak Hour Traffic Operations and Intersection Design at Wellesley and Newton Streets in Weston," August 17, 1999.

"Tech. Memorandum #2: Traffic Signal Coordination on Route 126, Framingham," March 30, 2000.

"Tech. Memorandum #3: Route 9/Route 27 Interchange, Natick," September 1, 2000.

"Tech. Memorandum #4: TMA Employer Data for Framingham Industrial Park and 9/90 Area—Comparison with 1990 Census Data," May 7, 1999.

1. INTRODUCTION

The current study originated in the Congestion Management System (CMS) planning efforts of 1997-98, which identified the MetroWest subregion as experiencing significant degrees of roadway congestion on both east-west and north-south arterial roadways. The MetroWest subregion contains nine towns: Ashland, Framingham, Marlborough, Natick, Southborough, Sudbury, Wayland, Wellesley, and Weston (**Figure 1-1**).

The principal tool used in the CMS planning process to identify congestion was a series of performance measures on which data were collected during 1997-98. These measures included:

- Roadway travel times, measured on many of the major arterials in this and other regions
- Roadway / intersection delays, measured as time in seconds (greater than a 3-second threshold) spent traveling at less than 5 mph on a segment
- Transit passenger loadings, defined as average passengers per seat during a defined period
- Transit schedule adherence on MBTA routes, where late arrivals are defined as trips arriving at their destination more than 5 minutes after the scheduled arrival time
- Percent vehicle occupancy at park & ride lots

The problems identified in MetroWest included generalized congested conditions along several arterials (Routes 16, 135 and 126), with congested segments along several others (Routes 30, 9, and 20), congestion at the Weston Toll Plaza on the Massachusetts Turnpike (MassPike), and crowded commuter rail park & ride lots on the Worcester commuter rail line.

The CMS field observation efforts were only the latest in the history of traffic studies in the MetroWest area, all of them highlighting the tendency toward increasing development and traffic growth in the area. In the 1980s, CTPS undertook a major multiyear study focusing on the Route 9 corridor through its length between Wellesley and Southborough. In 1987-91, a similar study was performed for the Route 20 corridor, again including the entire route between Weston and Marlborough. These studies are described in some detail in **Appendix A**. These two roadways (plus the MassPike) are the principal east-west arterial routes through the MetroWest area, connecting the major activity centers both within MetroWest and between MetroWest and the Boston and Worcester metropolitan areas.

North-south routes, including Routes 85, 126, 27, 16, and others, have attracted less planning attention over the years. This is principally because they tend to be lower-grade roadways: two-lane suburban roads, with mixed residential and commercial abutting development, serving to connect lower volumes of predominantly local traffic to the major east-west routes. However, these roadways too have become more crowded and congested within recent years, as evidenced by the travel-time run data.

It is worth noting that some roadway segments identified through travel-time runs as experiencing congestion are in the vicinity of existing signalized intersections and built-up areas with frequent curb cuts and on-street parking. At such locations, delays and start-stop travel conditions often result because of driveway movements and parking maneuvers, as well as the frequent need to yield the right of way at cross-streets and crosswalks.

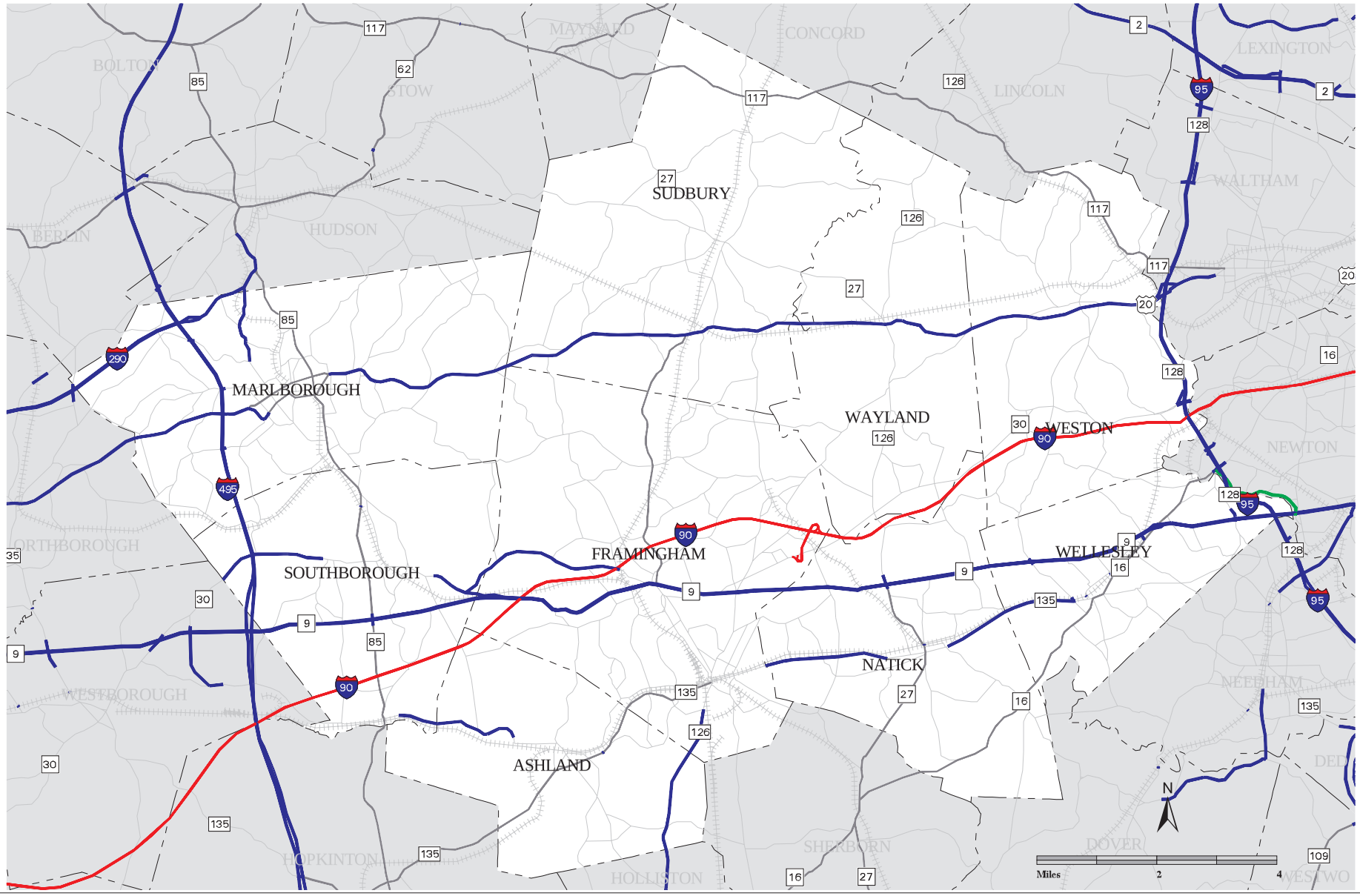
These interruptions are often referred to as "friction" or "turbulence," and are characteristic of operations in busy town centers and on city streets. They are not necessarily seen as problems by town officials in areas where slower vehicle speeds help enhance pedestrian safety and on-street parking is an indispensable commercial resource. In other areas, such conditions may indeed be viewed as undesirable symptoms of roadway congestion, which local officials may seek to alleviate through application of traffic engineering improvements and other measures. Before characterizing any such location as in need of congestion relief, it is advisable to determine whether providing relief by such means is regarded as a paramount objective by local officials.

The present study is not an attempt to redo the large planning studies of the 1980s and early 1990s. The predictions of those studies, with respect to continuing growth and development, and increasing traffic, continue to be relevant today, and need not be repeated.

Some of the recommendations of those earlier studies are in the process of being implemented, or are awaiting implementation when designs are finalized and/or funding becomes available. Other elements have not been advanced because of expressed public preferences in the MetroWest region. There is a strong desire in several of these communities to avoid solutions which would involve significant additions to existing roadway capacity, associated land-takings and environmental impacts. Therefore, approaches to managing congestion in the MetroWest area are likely to rely on small-scale improvements tailored to specific localized problems, rather than large-scale roadway improvements of potentially regional significance. This need to focus on localized solutions applies also to modes other than auto use, since traditional generalized transit services can not offer significant benefits to dispersed suburban areas such as MetroWest.

Still other recommendations, encouraging stricter controls on land use and development, have proven even harder to implement than roadway capacity additions. This is particularly true because local communities today are forced to rely on revenues from land development projects to supplement increasingly limited municipal budgets. To some extent, a "limited growth" stance is a luxury which only the more affluent MetroWest communities can afford to adopt, even though this is probably the most effective means of managing traffic growth.

This Phase I report aims to present a "snapshot" of existing growth and travel patterns in MetroWest, using currently-available data. This review will serve as a background for identifying and evaluating actions which have the potential to provide some degree of congestion relief at locations where remedial action is feasible and where such action



CTPS

MetroWest Subregional Area Study

Roadway Jurisdiction:

- MassHighway
- Mass. Turnpike Authority
- MDC
- Local

(Source: CTPS GIS/MassHighway)

Figure 1-1

Study Area Map: Roads by Administrative System

July 10, 2000 pl_mw-24int.aml

would be perceived as beneficial to MetroWest communities. The report identifies a short-list of readily identifiable planning tasks for CTPS effort, aimed at addressing localized congestion problems verified by town planners, with the hope of establishing a continuing dialog with towns about the most useful and practicable ways to address congestion. The report was developed in cooperation with the town planners from the nine MetroWest communities, as well as the MetroWest Growth Management Committee, whose help and contributions are gratefully acknowledged.

2. RECENT TRENDS: EMPLOYMENT, POPULATION, DEVELOPMENT

2.1. Employment

Table 2-1, based on data from the Massachusetts Department of Employment and Training (DET), summarizes total employment in the nine MetroWest communities as of 1998, with particular emphasis on the employment centers of Framingham, Natick and Marlborough.

As **Table 2-1** indicates, increases in the numbers of jobs within MetroWest communities during 1990-98 were concentrated in certain towns, particularly in Marlborough, Natick, Framingham, and Southborough. Growth in these towns was balanced to some extent by stability or decline in employment in other towns, most noticeably Sudbury's decline. In Framingham, it is worth noting (although not shown here) that the loss or downsizing of traditional large manufacturing plants had represented a major reduction in overall employment levels in the late 1980s; so that the Framingham value shown for 1990 in **Table 2-1** represents a considerable reduction from almost 47,000 in 1988.

While the total number of employed persons within MetroWest did not increase dramatically, the composition of employment *did* change, with a net loss in manufacturing areawide, and an increase in higher-end service, finance and trade employment. This trend toward increasing employment in service industries is most noticeable in Framingham, Marlborough and Natick (**Table 2-2**). Sudbury's manufacturing employment appeared to drop dramatically during this period. The drop may in part reflect changes in how multisite employment at Raytheon is reported to DET, and/or employee shifts between different plants for this major employer.

Table 2-3 illustrates current and anticipated employment levels in MetroWest, as forecast by the Metropolitan Area Planning Council. Compared with the levels of growth actually experienced by these towns by 1998, the overall total for Year 2000 is certainly in line with actual experience, although individual town forecasts may reflect somewhat faster or slower growth than the levels recorded by DET for 1998.

The forecasts reflect quite high levels of employment growth in Marlborough, which by itself is anticipated to account for almost one-half of overall MetroWest employment growth between 1990 and 2020. To a lesser degree, employment growth in Framingham and Natick is also expected to be relatively high. Other towns may exhibit higher percentages of employment growth, but only because their existing base is small compared with the larger towns. It is not clear that such high growth levels could

TABLE 2-1
Employment Change in MetroWest Communities, 1990-1998

	Total Employment by Year				
Community	1990	1995	1998	Absolute Change, 1990-1998	% Change 1990-1998
Ashland	4,075	3,796	4,159	84	2%
Framingham	39,047	37,895	41,666	2,619	7%
Marlborough	20,531	21,852	25,987	5,456	27%
Natick	19,331	20,626	23,033	3,702	19%
Southborough	4,097	4,676	5,405	1,308	32%
Sudbury	9,706	5,426	6,409	-3,297	-34%
Wayland	3,286	3,728	3,157	-129	-4%
Wellesley	18,203	17,698	18,324	121	1%
Weston	2,928	2,912	2,842	-86	-3%
TOTAL	121,204	118,609	130,982	9,778	8%

Source: Division of Employment and Training, *Employment and Wages in Massachusetts Cities and Towns 1988-1997*, ES-202 Program, updated to 1998 from DET website, July 2000.

TABLE 2-2
Average Annual Employment
By Major Industry Division

Town	Year	Total Employ-ment	Manu-facturing	% of Total	Wholesale, Retail Trade	% of Total	Finance Insurance Real Estate	% of Total	Services	% of Total
Ashland	1990	4,075	1,329	33%	1,116	27%	47	1%	592	15%
	1998	4,159	920	22%	1,270	31%	84	2%	699	17%
Framingham	1990	39,047	6,593	17%	11,302	29%	2,309	6%	12,398	32%
	1998	41,666	5,552	13%	11,657	28%	2,278	5%	15,171	36%
Marlborough	1990	20,531	8,556	42%	4,752	23%	572	3%	3,815	19%
	1998	25,978	7,094	27%	7,212	28%	582	2%	7,698	30%
Natick	1990	19,331	1,782	9%	7,663	40%	1,025	5%	4,427	23%
	1998	23,033	2,519	11%	8,561	37%	806	3%	7,690	33%
Southborough	1990	4,097	1,190	29%	1,013	25%	90	2%	912	22%
	1998	5,405	1,432	26%	969	18%	217	4%	1,521	28%
Sudbury	1990	9,706	5,787	60%	1,637	17%	93	1%	1,104	11%
	1998	6,409	1,788	28%	1,666	26%	135	2%	1,511	24%
Wayland	1990	3,286	281	9%	855	26%	106	3%	857	26%
	1998	3,157	145	5%	813	26%	82	3%	1,072	34%
Wellesley	1990	18,203	580	3%	4,252	23%	2,576	14%	8,842	49%
	1998	18,324	496	3%	3,637	20%	3,569	19%	8,819	48%
Weston	1990	2,928	60	2%	393	13%	378	13%	1,315	45%
	1998	2,842	37	1%	320	11%	262	9%	1,322	47%
OVERALL	1990	121,204	26,158	22%	32,983	27%	7,196	6%	34,262	28%
	1998	130,973	19,983	15%	36,105	28%	8,015	6%	45,503	35%

Note: Row totals do not add to 100%, because not all industry categories are shown.

Source: Division of Employment and Training, *Employment and Wages in Massachusetts Cities and Towns 1988-1997*, ES-202 Program, December 1998; supplemented with 1998 data from DET website, July 2000.

TABLE 2-3
Employment Forecasts for MetroWest Communities

Community	Total Employment by Year: 1990 Baseline	Estimated 2000	Estimated 2010	Estimated 2020	Absolute Change 1990-2020	% Change 1990-2020
Ashland	4,100	4,200	4,600	4,900	800	20%
Framingham	39,000	42,100	43,600	45,000	6,000	15%
Marlborough	20,500	27,100	33,600	38,000	17,500	85%
Natick	19,300	23,500	25,500	27,900	8,600	45%
Southborough	4,100	5,500	6,300	6,800	2,700	66%
Sudbury	9,700	6,600	7,600	8,500	-1,200	-12%
Wayland	3,300	3,200	3,500	3,700	400	12%
Wellesley	18,200	18,600	20,300	21,500	3,300	18%
Weston	2,900	2,800	3,000	3,100	200	7%
9-Town Total	121,100	133,600	148,000	159,400	+38,300	32%
Total MAPC region	1,699,100	1,820,100	1,972,200	2,120,100	421,000	27%

Source: Metropolitan Area Planning Council (latest update: website, current July 2000)

actually be sustained over this long a period without major and costly new investments in roadway infrastructure.

2.2. Population

Table 2-4 presents 1990 Census population totals, as well as interim-year population estimates also developed by U.S. Census, for MetroWest towns. **Tables 2-5** and **2-6** summarize currrent and projected population and households, respectively, as estimated by the Metropolitan Area Planning Council. As with employment forecasts, experience to date indicates that levels previously forecast for Year 2000 are on target. As in other parts of the metropolitan Boston region, numbers of households in MetroWest are growing faster than population, reflecting smaller family sizes and greater numbers of single householders. Population growth within MetroWest towns is

expected to occur at a somewhat higher rate than in Massachusetts as a whole, but at a lower rate than MetroWest employment growth.

Levels of both future employment and future population in these communities are subject to at least some degree of control by local officials, through zoning and local traffic and parking ordinances. Continued growth in jobs, particularly, will inevitably result in increased commuter traffic in this area, even if heroic attempts are made to divert new employees to alternative transportation modes. This is because even under ideal conditions for transit service, as described in the CTPS *Suburban Public Transportation* paper of 1998,[1] transit would be unlikely to attract more than a fraction of total trips; conditions for transit service are far from ideal in low-density, highway-dependent ex-urban areas like MetroWest. Increased carpooling and vanpooling opportunities are potentially much more successful, particularly at large employment clusters. But even these alternatives are likely to attract only a small fraction of trips overall, in the absence of dramatic employer *dis*incentives to single-passenger auto use.

TABLE 2-4
Population Change in MetroWest Communities, 1990-1998

	Total Population by Year				
Community	1990	1995	1998	Absolute Change, 1990-1998	% Change 1990-1998
Ashland	12,064	12,665	13,482	1,416	12%
Framingham	64,979	64,156	64,646	-343	-1%
Marlborough	31,808	32,675	33,278	1,465	5%
Natick	30,505	31,086	31,491	981	3%
Southborough	6,635	7,239	7,798	1,170	18%
Sudbury	14,356	14,854	15,550	1,192	8%
Wayland	11,872	11,892	12,343	469	4%
Wellesley	26,635	26,739	26,789	174	1%
Weston	10,198	10,352	10,651	451	4%
TOTAL	209,053	212,295	216,028	6,975	3%

Source: Population Estimates Program, Population Division, U.S. Census Bureau, Washington, DC 20233 (SU-98-8) Population Estimates for Minor Civil Divisions: Annual Time Series,July 1, 1990 to July 1, 1998. Internet Release Date: June 30, 1999

[1] Central Transportation Planning Staff, *Suburban Public Transportation*, by Stephen Falbel *et al.*, August 1998. According to this report, successful transit services require sufficient residential and employment densities, good walking environments, and a mix of different land uses (pp. 8-9).

TABLE 2-5
Population Forecasts for MetroWest Communities

Community	Total Population by Year: Assumed 1990 Baseline	Esti-mated 2000	Esti-mated 2010	Esti-mated 2020	Absolute Change 1990-2020	Percent Change 1990-2020
Ashland	12,066	14,601	16,321	18,351	6,285	52%
Framingham	64,989	66,775	66,941	67,654	2,665	4%
Marlborough	31,813	35,405	37,891	40,302	8,489	27%
Natick	30,510	31,317	31,677	32,121	1,611	5%
Southborough	6,628	8,483	9,197	10,182	3,554	54%
Sudbury	14,358	15,937	16,702	17,511	3,153	22%
Wayland	11,874	12,615	12,273	12,448	574	5%
Wellesley	26,615	26,890	27,898	28,041	1,426	5%
Weston	10,200	11,160	11,818	12,322	2,122	21%
9-Town Total	209,053	223,183	230,718	238,932	29,879	14%
Total MAPC region	2,922,934	3,064,485	3,127,051	3,229,591	306,657	11%

Source: Metropolitan Area Planning Council (latest update: website, current July 2000)

TABLE 2-6
Household Forecasts for MetroWest Communities

Community	Total Households by Year: Assumed 1990 Baseline	Estimated 2000	Estimated 2010	Estimated 2020	Absolute change 1990-2020	Percent change 1990-2020
Ashland	4,607	5,695	6,486	7,460	2,853	45%
Framingham	25,113	26,164	26,419	27,179	2,066	7%
Marlborough	12,152	13,734	14,911	16,130	3,978	19%
Natick	12,009	12,595	13,200	13,992	1,983	15%
Southborough	2,281	3,002	3,351	3,844	1,563	53%
Sudbury	4,762	5,415	5,863	6,403	1,641	33%
Wayland	4,210	4,571	4,579	4,817	607	29%
Wellesley	8,472	8,789	9,431	9,820	1,348	13%
Weston	3,350	3,841	4,198	4,542	1,192	37%
9-Town Total	76,956	83,806	88,438	94,187	17,231	22%
Statewide Total	1,111,708	1,184,204	1,239,106	1,298,404	186,696	17%

Source: Metropolitan Area Planning Council (latest update: website, current July 2000)

2.3. Development/Growth Centers

A number of major centers of employment activity have developed within MetroWest with the active encouragement of town officials; these include:

- The upper Speen Street / Old Connecticut Path area in Framingham's "Golden Triangle"
- The Framingham Technology Park and 9 / 90 Crossing developments, at the junction of Route 9 and the MassPike in western Framingham
- The Marlborough industrial area, in the vicinity of the planned new interchange on I-495 south of Forest Street
- Route 9 in Natick, between the Route 27 interchange and Oak Street

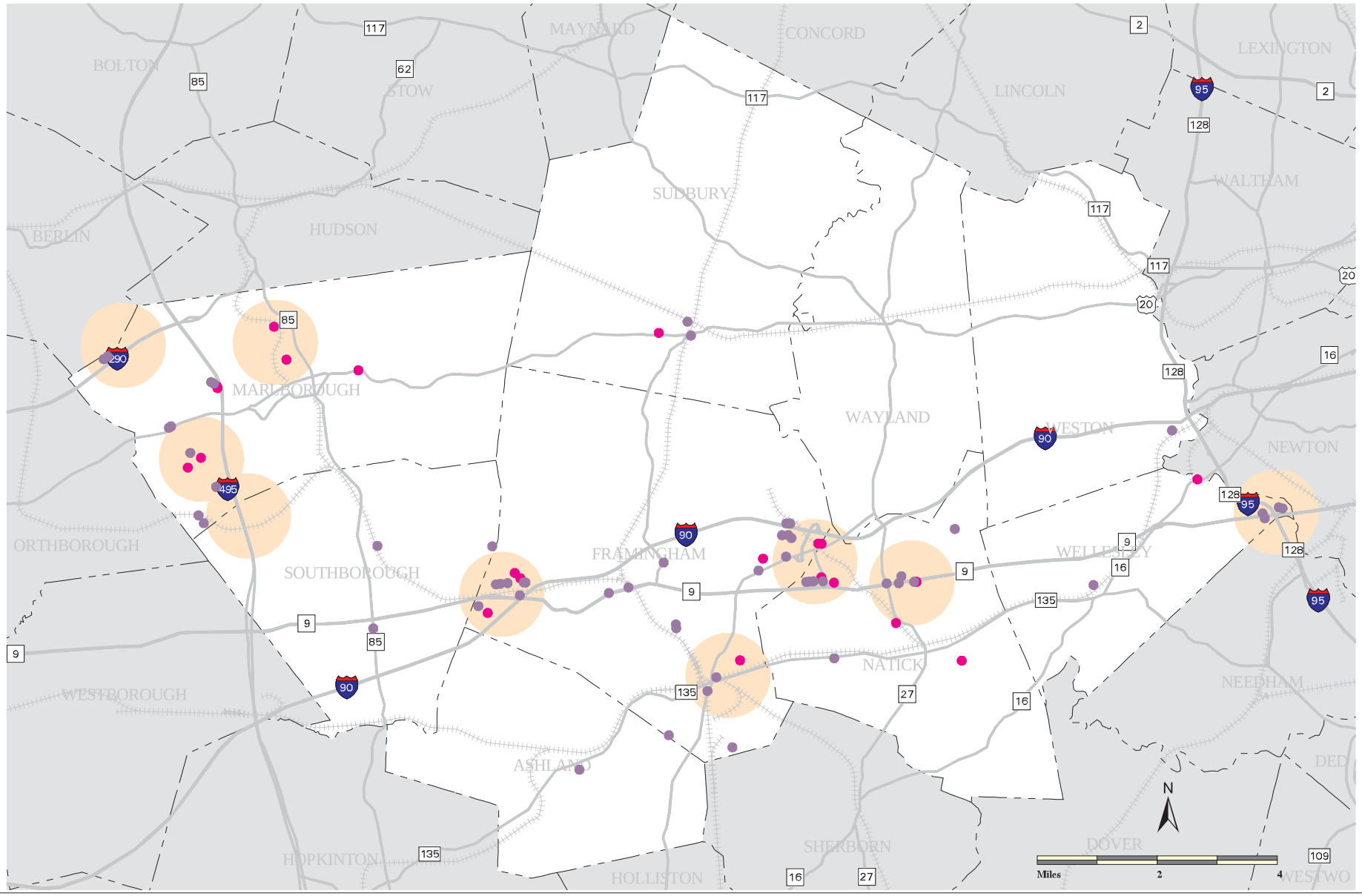
These are highlighted as clusters on **Figure 2-1**, which shows the locations of many of the largest employers currently operating within the nine-town area (classed by size in

Table 2-7). These cluster locations are all continuing to grow: **Figure 2-2** highlights recent commercial and industrial development initiatives within the nine-town area, as catalogued by the MetroWest Growth Management Committee in the spring of 1998; while **Table 2-8** provides a listing and partial status update on these developments. To a large extent, these growth plans represent expansions of businesses which already have a presence in MetroWest. But new businesses continue to relocate to the area, attracted by receptive policies toward growth.

The I-495 corridor has received particular attention during the past several years, as the result of initiatives undertaken by elected officials, the Massachusetts Technology Collaborative, the Metropolitan Area Planning Council, and cities and towns adjacent to I-495. The mission of the I-495 Technology Corridor Initiative is to serve as a regional forum on growth within these cities and towns. Objectives include assessing the impact of economic growth on municipalities, particularly with respect to quality-of-life issues; developing a vision of the corridor's future, given the objectives and values of individual member communities; and generating ideas for solving growth-related problems, including transportation-related issues.

Both the MetroWest area and the I-495 member communities are confronting the issue of suburb-to-suburb commuting, which is becoming more intense as job growth continues. The densities of suburban locations, particularly those in which new office/R&D development are taking place, are generally too low to allow them to be served effectively by traditional transit services. Older, more concentrated "downtowns", such as those in downtown Framingham and downtown Marlborough, with large resident populations having relatively low auto availability, and/or who do not have to travel far to work, lend themselves much more readily to traditional fixed transit services, for work, shopping, personal business, and other such trips. Framingham's LIFT is successful at attracting moderate ridership because it targets appropriate transit markets, centered on the downtown Framingham "core". Such services do require long-term subsidies in order to continue operating.

More typically, the dispersed natures of both suburban residential patterns and suburban employment clusters—especially within "office park" settings such as the newer Framingham and Marlborough clusters—mean that fixed-route transit travel times are almost never competitive with auto travel times for groups of employees large enough to justify implementing transit services. Much of the ample open land area within these office parks is devoted to free employee parking, which represents another irresistible incentive to commuting by car for the vast majority of suburban employees. Finally, the occupants of these office parks are *not* traditional transit commuters—their income levels typically allow high levels of household auto ownership, which allow them to live long distances from work sites.



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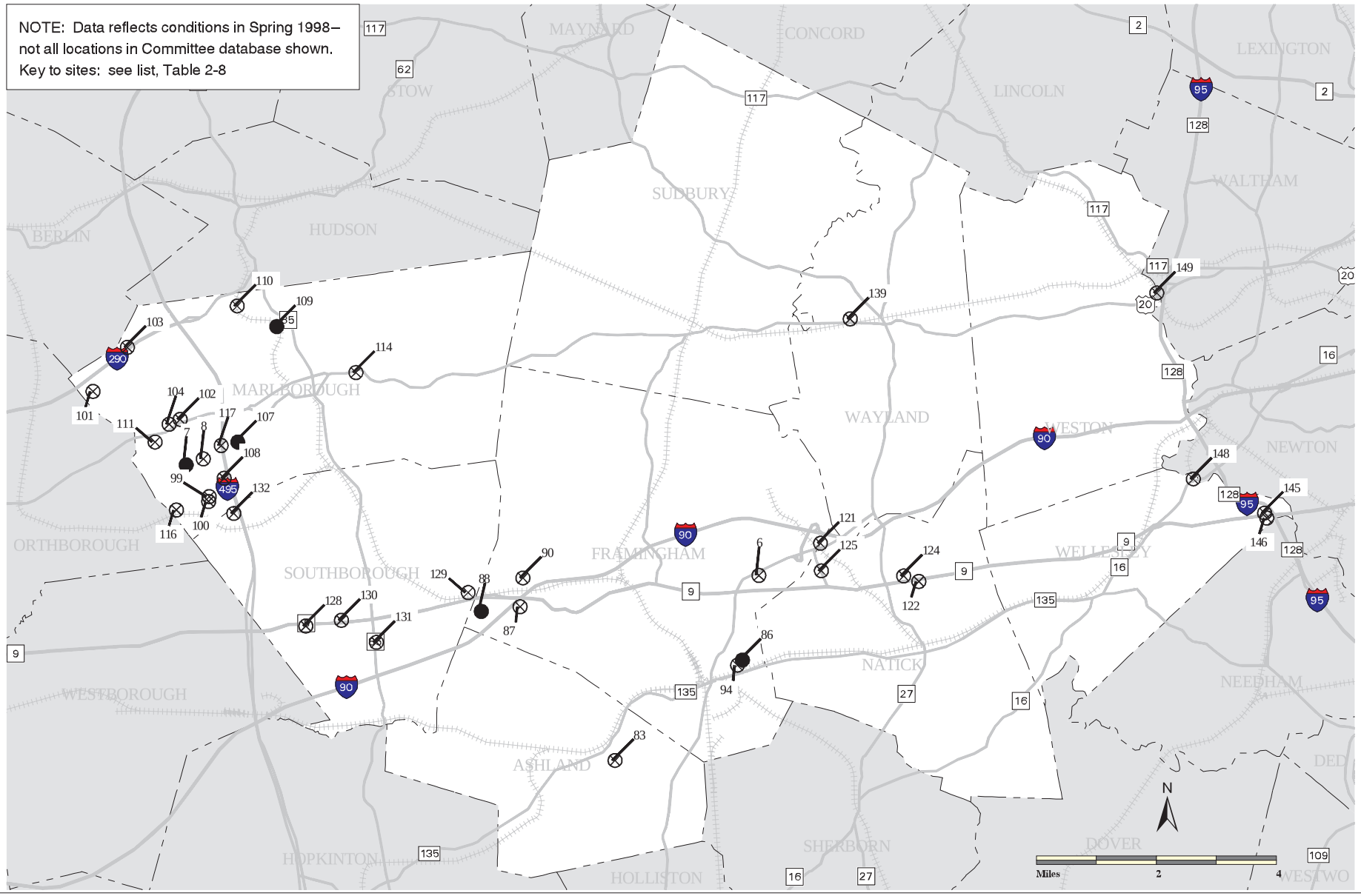
Site: 200-500 employees
Site: More than 500 employees
Large industrial concentration

(Source: Dun & Bradstreet/MW Chamber of Commerce)

Figure 2-1
Large Employers in MetroWest

July 11, 2000 pl_mw-02emp.aml



Development Size

⊗ **Less than 500 ksf**

● **500 ksf or more**

(Source: MetroWest Growth Management Committee database)

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MetroWest Subregional Area Study

Figure 2-2
Recent and Pending Development in MetroWest (Industrial/Commercial Only)

July 11, 2000 pl_mw-21dev.aml

TABLE 2-7
Large Employers in Metrowest

Town	Employer
1. Employer Sites With More than 500 Employees	
Framingham	Bose Corporation
	Dennison Manufacturing
	Marshall's of MA, Inc.
	TJX Companies, Inc.
Marlborough	Ascent/Lucent Technologies
	Compaq
	Marlborough Hospital
	New England Telephone/NYNEX Corporation
	Raytheon Company
Natick	BJs Wholesale Club Inc.
	Boston Scientific Corporation
	Chirex Inc.
	Columbia Metrowest Medical Center
	Dept. of the Army/Natick Labs
	Interstate Brands/Continental Baking
Sudbury	Raytheon Company
Wellesley	Summit Services Group, Inc.
2. Employer Sites With 200-500 Employees	
Ashland	Kidde-Fenwall Inc.
Framingham	Adesa Corporation
	Advocates, Inc.
	Bose Corporation
	Community Newspaper/MW Daily News
	Computerworld, Inc.
	Fabric Place
	Good Humor Corporation
	International Data Corporation
	Lumber Mutual Insurance
	Perini Corporation
	Ryder Student Transportation Services
	St. Patrick's Manor Inc.
	Staples, Inc.
	Starwood Hotels/Sheraton Tara
	Stop & Shop
	TLC Nursing
	U.S. Postal Service
	Visiting Nurses Association
Marlborough	A & L Realty/Best Western Hotel
	CompUSA, Inc.
	Fidelity
	Hemasure, Inc.
	Ken's Foods, Inc.
	May Department Stores/Filene's

Marlborough (cont'd)	Qualex, Inc.
	Rohm & Haas Company
	The Rockport Company
	ViewLogic Systems, Inc.
Natick	Advanced Janitorial Service
	Cognex Corporation
	Macy's East
	Mathworks, Inc.
	May Department Stores/Filene's
	May Department Stores/Lord & Taylor
	Professional Dental Associates
	Roche Bros. Supermarkets
	Stop & Shop Companies
Southborough	Commonwealth Gas
	New England Primate Research Center
	Southborough Medical Group, Inc.
Sudbury	Chiswick Trading, Inc.
	Roche Bros. Supermarkets
Wellesley	EG&G, Inc.
	Harvard Pilgrim Health Care
	Roche Bros. Supermarkets
	Sun Life Assurance Company
	Watson Wyatt & Company
Weston	SableEast Corporation

Sources: Dun & Bradstreet *Regional Business Directory* (1998), supplemented by Dun & Bradstreet *Microcosm* (1997/98), and discussions with local Chambers of Commerce, 1998-99.

TABLE 2-8
New and Pending Developments in MetroWest
(Industrial/Commercial Only)

Site-ID#	City	Title	Dev. Type	Location	Size	Status
83	Ashland	Lt. Industry / R&D	Industrial, Light	Chesnut St. Sandpit	50,000 sf	Proposed
6	Framingham	Barmakian Jewelers	Commercial Retail	Rte 30 Mall	25,000 sf	Under Construction
86	Framingham	Dennison		Dennison Ave.	650,000 sf	Delayed
87	Framingham	Boston Properties	Hotel and Office	Turnpike Property - Exit 12 Loop Ramps (Calif.Ave)	300,000 sf + hotel (150 rooms)	On hold--awaiting rezoning
88	Framingham	9/90 Crossing	Office	Intersection of Rt.9 and I-90	1,500,000 sf	Partly occupied
90	Framingham	Bose Phase 3-5	Office	Mountain Rd	410,000 sf	Completed
94	Framingham	Lifeline		Dennison Bldg. -- Clarke St.	80,000 sf	Occupied
NS*	Framingham	Fafard	Office	Pleasant St. Ext.	27,000 sf	Proposed
7	Marlborough	3COM	Office	Crane Meadow	1,200,000 sf	Occupied
8	Marlborough	Compaq	Office	Forrest Street	350,000 sf	Occupied
99	Marlborough	Crane Meadow Office Bldg	Office	Crane Meadow Rd	160,000 sf	Occupied
100	Marlborough	Crane Meadow Office Bldg	Office	Crane Meadow Rd	50,000 sf	Permitting
101	Marlborough	Waterford Park	Office	I-290/Robin Hill	450,000 sf	Permitting
102	Marlborough	Homestead Village	Extended Stay	Rt 20 W	67,500 sf	Completed
103	Marlborough	2 Spec Office buildings	Office	Donald Lynch Blvd.	120,000 sf - 60,000 each	
104	Marlborough	Hampton Inn	Hotel/Motel	Rt 20 W/Bronx Park	88,000 sf	Completed
107	Marlborough	Williams Corp. Center	Hotel and Office	Williams St. @ Lizotte Dr.	515,000 sf office & hotel (130 rooms)	Permitting
108	Marlborough	Fidelity	Office	Simarano Dr.	400,000 sf	Completed
109	Marlborough	Lucent	Office	Addition Hill	500,000 sf	Approved
110	Marlborough	International Corporate Ctr	Office	Fitchburg St.	600,000 sf	Permitting
111	Marlborough	Windsor Corp.	Office	Rt. 20/Hayes Blvd.	235,000 sf	Approved
114	Marlborough	Post Rd Plaza Expansin	Commercial Retail	Rt 20/Hosmer St	96,640 sf	Approved
116	Marlborough	Spec. Office Bldg.	Office	Cedar Hill	65,000 sf	Under Construction
117	Marlborough	Spec. Office Bldg.	Office	Forest Street	120,000 sf	Partly occupied
NS	Marlborough	Hotel	Hotel/Motel	Solomon Pond / I-290	130 rooms	Planned
NS	Marlborough	Hotel	Hotel/Motel	I-495 / Elm St.	130 rooms	Planned
NS	Marlborough	Target Retail Store	Commercial Retail	Donald Lynch Blvd. - near Soloman Pond Mall	150,000 sf (est.)	Withdrawn
121	Natick	TJX	Office	Rt. 30/Speen St.	273,000 sf	Planned
122	Natick	Mathworks	Office	Apple Hill & Cochituate Place	312,985 sf total - 210,587 sf in Apple Hill and 102,398 sf in Cochituate Place.	Almost completed
124	Natick	Cognex - expansion	Office	Natick Office Park Rt.9		Planned
125	Natick	Continental Bakery	Commercial Retail	Speen St.		In negotiation
NS	Natick	Homestead Village	Hotel/Motel, Extended Stay	Speen St.	144 units	Proposed
128	Southborough	N.E. Printing Associates		Crystal Pond/Rt.9	14,000 sf	Completed
129	Southborough	Firmin / Willow St. Office Bldg.	Office	Firmin/Rt. 30 intersection	40,000 sf	Under Construction
130	Southborough	Deerfoot Office Park	Office	Rt.9	44,000 sf	Under Construction
132	Southborough	Maggiori	Office	Northborough Rd	2 bldgs: 172 ksf, 120ksf	Permitting
NS	Southborough	200 Tech Realty Trust	Office/Warehouse	Off Northborough Road	148,606 sf	Under Construction
NS	Southborough	Newton Street LLC	Office	Newton Street (24-28)	42,764 sf	Permitting
NS	Southborough	Reservoir Corp. Center	Office	Rt.9/Breakneck Hill Rd.	100,000 sf	Under Construction
139	Wayland	Raytheon/Polaroid	Office	Rt 20 W of Rt 27/126	435,000 sf	Partly occupied
145	Wellesley	Harvard/Pilgrim	Office	Rt.9/Rt.128	270,000 sf	Under Construction
146	Wellesley	Sun Life	Office	Rt.9/Rt.128	170,000 sf	Proposed
148	Wellesley	Super Stop-n-Shop	Commercial Retail	Rt.16	50,000 sf	Proposed
149	Weston	Arthur D. Little	Office	Rt. 20/Rt. 128	350,000 sf	On hold

I.D. number that appears in Figure 2-2

* NS = Not shown--exact location to be clarified

(Source: MetroWest Growth Management Committee database--status updated to Spring 1999 where possible)

Efforts have been made, particularly by the MetroWest Transportation Management Association (TMA) in conjunction with the MetroWest Chamber of Commerce, to identify employers among these expanding businesses who are willing to take an aggressive role in sponsoring ride-sharing initiatives, including carpooling, vanpooling, shuttle bus services to transit stations, reverse-commuting bus service, and other initiatives. Even the areas of industrial development which appear as clusters in Framingham, Natick and Marlborough do not achieve sufficient employment densities to justify transit services adequate to attract more than a small handful of riders—primarily those few who have no auto-based alternatives.

As an example, several major employers in the Framingham Technology Park—9/90 Crossing complex, located on both sides of Route 9 at the western end of Framingham, participated in employee surveys conducted by the MetroWest TMA. This area is a relatively concentrated suburban employment center, compared with other locations in MetroWest, and one which is continuing to grow. However, the survey data indicated that the residence locations of employees are widely dispersed across the eastern Commonwealth, and include the neighboring states. No reasonable potential market area could be defined exhibiting sufficient employee density for traditional fixed-route bus service.

This area, particularly 9/90 on the south side of Route 9, is organized in a way similar to many suburban office parks, with wide, campus-like settings for buildings which are set far apart and surrounded by large parking lots. A calculation of employment density for just the land parcel which contains the Framingham Technology Park indicates a likely maximum density of around 6,500 employees in a 0.46 square-mile area. This represents about 14,000 jobs per square mile; or about 23 employees per acre.

This is below employment levels and densities which can support basic bus service. Studies of suburban activity centers comparable to the Technology Park suggest a threshold for employee-based bus service of about 50-60 employees per acre, with a total employment base of 10,000 or more.[2] **Table 2-9** illustrates the relative densities and drive-alone/transit mode shares for selected centers.[3] The density of Framingham Technology Park is comparable to the lower-density sites in **Table 2-9**, which typically have drive-alone mode shares greater than 90 percent

And 9/90 appears to be developing on a model of even lower density than the Framingham Technology Park. Neither site could be described as "pedestrian-friendly" or transit-friendly: these sorts of environments fail to meet the criteria outlined in the *Suburban Public Transportation* paper for successful transit operation.

With vigorous employer involvement, ride-sharing programs could be much more successful at these locations than they are at present. Success at ride-sharing generally

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[2] Cervero, Robert, *Transit-Supportive Development in the United States: Experiences and Prospects*, prepared for U.S. Department of Transportation Federal Transit Administration, December 1993, p. 46.

[3] Hooper, Kevin G., *Travel Characteristics at Large-Scale Suburban Activity Centers*, National Cooperative Highway Research Program Report 323, October 1989; presented in Cervero, *op. cit.*, p. 17, with additional data from original report.

TABLE 2-9
Characteristics and Work Trip Mode Splits, Selected U.S. Suburban Activity Centers

Center	Location	Distance from CBD (Miles)	Total Employ-ment	Density (Employ-ment / Acre)	Drive-Alone Auto*	Passen-ger Auto*	Transit (Bus)*
Bellevue	Seattle, WA	10	19,030	43.2	73.9	16.9	8.8
South-Coast Metro	Orange County, CA	45	17,330	29.9	92.5	6.4	0.0
Parkway Center	Dallas, TX	10	48,375	25.9	94.2	5.6	0.2
Perimeter Center	Atlanta, GA	12	42,430	29.3	93.0	6.5	0.5
Tysons Corner	Washington, D.C.	12	37,650	30.6	89.2	9.8	0.7
Southdale	Minneapolis, MN	10	19,855	20.7	92.1	6.6	0.8
Framingham Tech. Park	Framingham, MA	20	6,700 (est.)	22.7 (est.)	90.0	8.3	0.3

* It is worth noting that, in addition to having high employee densities, Bellevue has predominantly fee-based parking at office buildings, with employee parking fees as high as $60 per month [Hooper, p. 46]). Cervero notes that, at one Bellevue building with restricted and expensive parking, transit share was 12 percent and carpool share was 37 percent; while at another nearby building, with free and plentiful parking, only 11 percent of workers either carpooled or used transit [Cervero, p. 16].

Sources: (all except Framingham) Hooper, Kevin G., *Travel Characteristics at Large-Scale Suburban Activity Centers*, National Cooperative Highway Research Program Report 323, October 1989; presented in Cervero, *op. cit.*, p. 17, with additional data from original report. (Framingham) Employment estimated from CTPS 1996 database; modal split information from 1990 Census.

results when employers help create incentives to employee involvement, such as rewards for long-term vanpools; as well as disincentives to discourage driving alone, such as parking charges or restrictions.

Absent such active employer promotion and support, the continuation of past and present trends toward large-scale development at low densities with unrestricted parking availability, designed primarily to facilitate automobile access, acts to 'build in' incompatibility with transportation via shared-ride modes.

3. RECENT TRENDS: TRANSPORTATION

3.1. 1990 Census Data

The 1990 Census Data still represents the only comprehensive source of information about detailed commuting behavior at town and subtown levels. Hence, even at the end of the decade, this database is still referenced as a source of information about travel trends in particular localities. It is the primary data source for the *Suburban Public Transportation* paper, which used Journey-to-Work data as the basis of maps showing the distribution of employee origins throughout the metropolitan Boston region. While any analysis drawn from this data needs to be tempered by the recognition that the economic and employment scenes have changed since 1990, such analysis can at least represent a benchmark against which more recent data can be compared.

One useful way to use this data is to identify towns, or block groups within towns, with characteristics which vary from areawide averages, and to determine the reasons for such differences. For example, using Census work-trip data tabulated at the home end, **Figure 3-1** illustrates the block groups within MetroWest which reported more than a 5 percent "commuter rail" mode share, and those which reported more than a 10 percent share. Obviously, the highest density of commuter rail use can be found in those block groups which are closest to the railroad right-of-way and stations. The highest commuter rail *shares* and *numbers of trips* identified in the 1990 Census are identified with neighborhoods in Wellesley and Natick which are directly adjacent to the Wellesley Hills and West Natick train stations.

Similarly, the areas with the highest "walk" mode shares are those which contain, or are adjacent to, colleges: the area surrounding Wellesley College has by far the highest *share* (almost 60%) and the highest *number* (over 700) of walk-to-work trips. The highest "work-at-home" shares are found exclusively in Weston and Wellesley, but in no case do these represent more than 65 people in a single block group.

Table 3-1 summarizes, at the town level, the numbers of work trips by mode with their residential end within MetroWest. In addition, the number of work trips by mode with their work end within MetroWest is shown in **Table 3-2** for selected MetroWest towns. The data in **Table 3-2** are derived indirectly, from Census surveys obtained at households rather than work sites, and therefore are not as reliable for all towns as the "home end" data of **Table 3-1**. Weston and Wayland are omitted from **Table 3-2**

because of inconsistencies between total work trip ends reported for these towns and the DET employment data for these towns in the same year.

3.2. Traffic Volumes

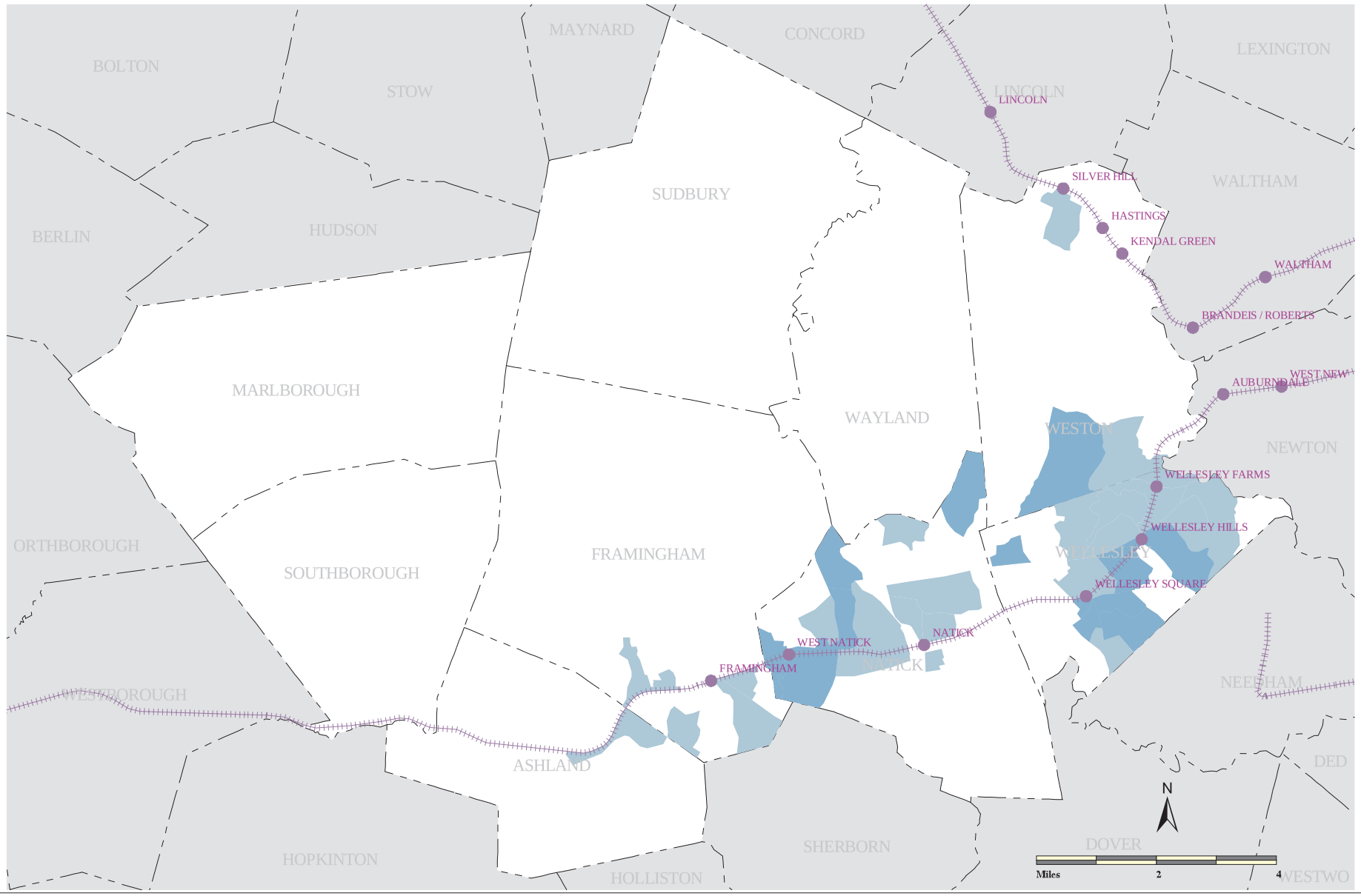
An inventory was made of 24-hour traffic counts from MassHighway files, as well as from selected major consultant studies in the MetroWest towns. The objective was to identify locations, principally on major roadways or numbered routes, where several years' worth of traffic count data could be compiled and compared, in order to observe growth patterns and trends on these roadways. **Figure 3-2** illustrates these locations, which include multiple points on Route 9 and Route 20, as well as several north-south routes (including Route 85 and Speen Street). **Appendix B** contains graphs illustrating daily variations in traffic over time, based on the collected volumes.

It should be noted that data for Route 9 and for Route 20 west of I-495 reflect the existence of two or more travel lanes in each direction; the remaining roadways generally have one travel lane each way, except for turning lanes provided at intersections.

(1) Route 9

Figures B-1 through **B-4** in **Appendix B** illustrate directional traffic volumes at four points along Route 9 over a period of years. The volumes as presented have NOT been seasonally adjusted or otherwise modified, for the following reasons:

- The volume sources include developer studies, which were not adjusted by the same factors which MassHighway would have used for its own counts.
- It is not clear how even MassHighway's seasonal adjustment factors apply to hourly traffic volumes. The factors are typically used to develop estimates of ADT and AWDT, rather than to normalize hourly counts; while the principal interest here was to observe hourly volume trends (e.g., variability of peak vs. off-peak volumes hour-by-hour).
- Use of the raw count data, typically averaged over several days during the months noted, was intended to illustrate robustness of the general trends at a particular location over different seasons and over time.



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Commuter Rail Mode Share = 5%-10%
Commuter Rail Mode Share > 10%
Active CR Line

(Source: 1990 Census Journey-to-Work, Table U130)

Figure 3-1
1990 Census: Block Groups with High Commuter Rail Share

July 11, 2000 pl_mw-03cen.aml

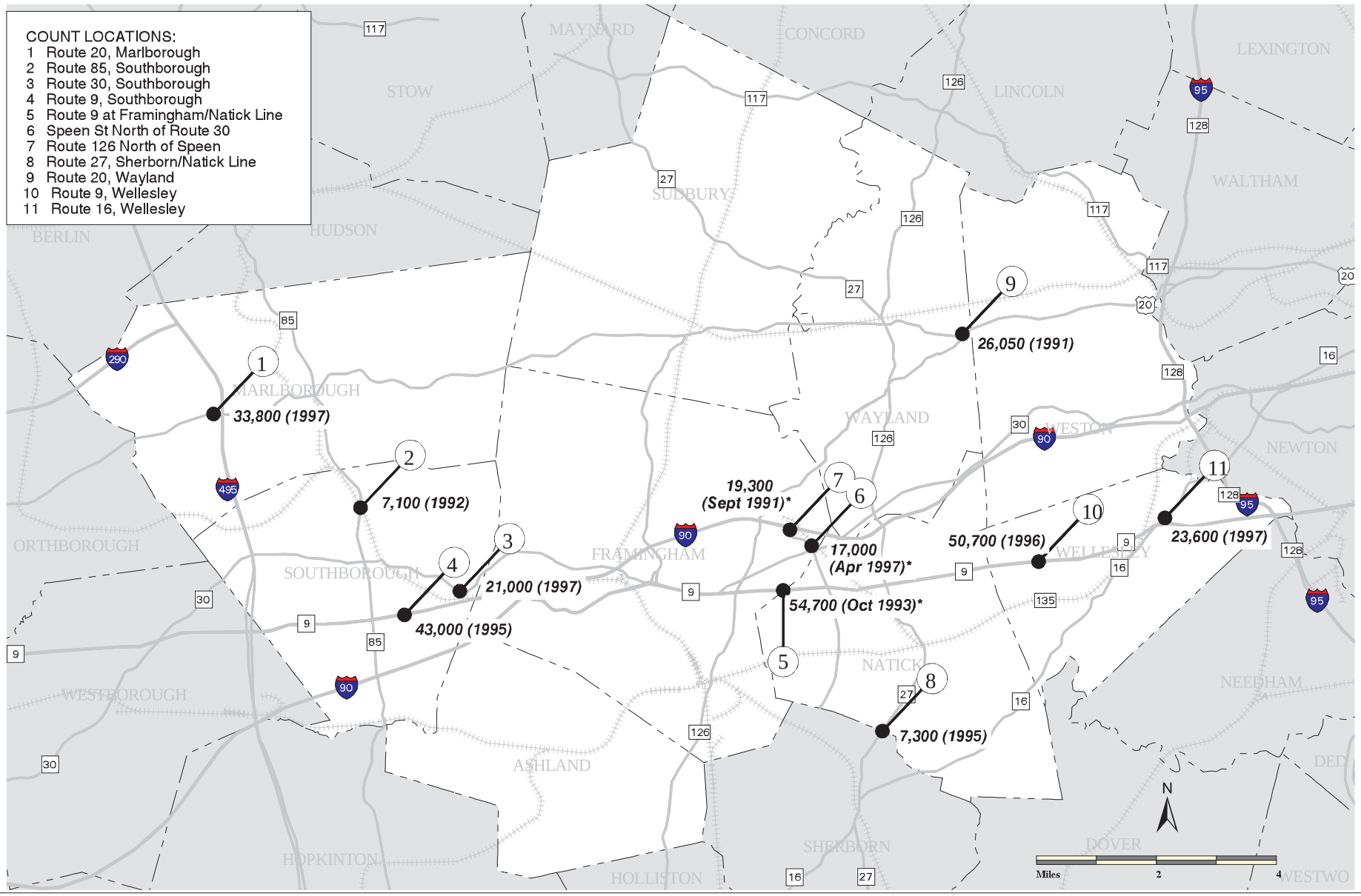
TABLE 3-1
1990 Census: Work Trip Modes
by Town of Residence

Town	Total Trips	Drive Alone	Carpool (2+)	Bus / Subway	Commuter Rail	Bike / Motorcycle	Walk to Work	Work at Home	Other
		Work Trips by Mode: Number / **Percent of Total**							
Ashland	7,058	5,902	563	20	205	23	88	236	21
		84%	**8%**	**0%**	**3%**	**0%**	**1%**	**3%**	**0%**
Framingham	36,071	29,054	3,712	392	596	182	1,230	765	140
		81%	**10%**	**1%**	**2%**	**1%**	**3%**	**2%**	**0%**
Marlborough	17,716	14,638	2,214	57	57	48	369	249	84
		83%	**12%**	**0%**	**0%**	**0%**	**2%**	**1%**	**0%**
Natick	17,456	13,582	1,657	202	1,005	66	456	396	92
		78%	**9%**	**1%**	**6%**	**0%**	**3%**	**2%**	**1%**
Southborough	3,563	2,997	222	22	13	15	152	128	14
		84%	**6%**	**1%**	**0%**	**0%**	**4%**	**4%**	**0%**
Sudbury	7,813	6,692	445	92	56	23	134	337	24
		86%	**6%**	**1%**	**1%**	**0%**	**2%**	**4%**	**0%**
Wayland	6,282	5,223	381	128	98	16	80	342	14
		83%	**6%**	**2%**	**2%**	**0%**	**1%**	**5%**	**0%**
Wellesley	13,041	8,780	828	273	874	64	1,489	646	81
		67%	**6%**	**2%**	**7%**	**0%**	**11%**	**5%**	**1%**
Weston	5,049	3,734	252	165	166	5	236	469	22
		74%	**5%**	**3%**	**3%**	**0%**	**5%**	**9%**	**0%**
OVERALL	114,049	90,602	10,274	1,351	3,070	442	4,234	3,568	492
		79%	**9%**	**1%**	**3%**	**0%**	**4%**	**3%**	**0%**

TABLE 3-2
1990 Census: Work Trip Modes
by Town of Workplace

Town	Total Trips	Work Trips by Mode: Number / **Percent of Total** Drive Alone	Carpool (2+)	Bus / Subway	Commuter Rail	Bike / Motorcycle	Walk to Work	Work at Home	Other
Ashland	4,305	3,388	517	28	0	15	94	236	27
		79%	**12%**	**1%**	**0%**	**0%**	**2%**	**5%**	**1%**
Framingham	36,502	30,637	3,528	122	42	139	1,162	765	107
		84%	**10%**	**0%**	**0%**	**0%**	**3%**	**2%**	**0%**
Marlborough	25,942	22,284	2,676	109	0	95	385	249	144
		86%	**10%**	**0%**	**0%**	**0%**	**1%**	**1%**	**1%**
Natick	19,538	15,954	2,357	168	20	89	498	396	54
		82%	**12%**	**1%**	**0%**	**0%**	**3%**	**2%**	**0%**
Southborough	4,771	4,013	435	24	0	25	152	128	8
		84%	**9%**	**1%**	**0%**	**1%**	**3%**	**3%**	**0%**
Sudbury	5,968	4,848	583	75	0	19	80	337	26
		81%	**10%**	**1%**	**0%**	**0%**	**1%**	**6%**	**0%**
Wayland*									
Wellesley	18,704	14,605	1,391	211	67	100	1,615	646	69
		78%	**7%**	**1%**	**0%**	**1%**	**9%**	**3%**	**0%**
Weston*									
OVERALL	115,730	95,729	11,487	737	129	482	3,986	2,757	435
(7 towns only)		**83%**	**10%**	**1%**	**0%**	**0%**	**3%**	**2%**	**0%**

***Not reported because work trip totals not consistent with DET totals



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ADT Volume (Date)

Count Location
(* identifies non-MHD count)

(Source: CTPS GIS/MassHighway)

Figure 3-2
Historic Traffic Count Locations

July 11, 2000 pl_mw-05cou.aml

The most striking feature of these data is the high volumes observed throughout the length of Route 9, and the variation in daily flows at different points on this roadway. Route 9 in Southborough exhibits a typical commuter traffic pattern: i.e., high volumes during a morning and evening peak period, with a "dip" representing midday traffic. Similar patterns are observed on Route 20 in Marlborough. On both roadways, traffic volumes declined markedly in the early 1990s, compared with the peaks of the late 1980s; but volumes have been growing back to, and beyond, previous levels on both roadways since that time. The growth in traffic volumes, while not spread uniformly over the day, has been at least somewhat distributed over peak and nonpeak hours. While both roadways may be approaching capacity for peak-directional operations, in comparison with other sections of Route 9 they operate at tolerable or acceptable levels over a good portion of the day, and the peak periods appear to fill up and drop off relatively quickly.

To some extent, this is also true of the section of Route 9 between Cedar Street and I-95 (Route 128): clear traffic peaks are set by commuter activity, associated with Route 128 commuter demand and the businesses and office park located along Route 9 in this section of Wellesley.

Route 9 in the Weston Road area presents a slightly different picture, because virtually all the observed difference among the years presented occurs during the mid-day off-peak period, with not much observed difference in the maximum volumes obtained during the morning and evening peaks. The evening peak period has spread into the late afternoon in the later count. This trend toward diffuse traffic demands over a larger part of the day reaches its limit on Route 9 at the Framingham / Natick town line. At this location, a combination of commuter traffic (including traffic generated by local businesses) and shopper / other traffic serves to keep volumes high through most of the daytime. The maximum through hourly volumes at this location are slightly lower than at other points along Route 9, possibly because the frequent traffic signals and driveway intersections in this area tend to slow traffic down and reduce the practical capacity of the roadway.

(2) Route 20

For Route 20, diagrams which show daily traffic patterns illustrate the peaking tendencies in both sections of the roadway (**Figures B-5** and **B-6, Appendix B**). The section in Marlborough is four lanes wide. Its peaking pattern resembles that of Route 9 in Southborough, with strongly defined morning and evening peak periods (eastbound in the morning, westbound in the evening) and a relatively low-volume midday. The peaks are clearly set by industrial traffic coming from I-495 and from Marlborough itself, toward the industrial concentrations north and south of Route 20. Both the peaks and the midday volumes are continuing to grow, reflecting continued development served by Route 20 in this area and the available capacity provided by four lanes in this area. Over time, the PM peak in particular is tending to expand to include earlier hours of the midday period.

Farther east, Route 20 in Wayland has only a single lane in each direction. Directional peaks are much less strong in this section, with eastbound and westbound traffic flows

of comparable magnitudes. This probably reflects the limited capacity of the roadway, and the fact that both morning and evening peaks spread out towards midday.

(3) Other area roadways

The pattern observed on Route 20 in Wayland is very similar to that observed on other nearby two-lane roadways, such as Speen Street north of Route 30 in Wayland and, to a lesser extent, Route 85 in Southborough (**Figures B-7** through **B-10, Appendix B,** for graphs). These roadways serve mainly residents of abutting towns, including trips of varying purposes which occur throughout the day, not just at peak hours.

Route 16 in Wellesley and Route 30 in Southborough exhibit more directional trends: Route 30 graphs look similar to those for Route 9 (although with lower volumes) because traffic at this location is determined primarily by the industrial attractions at Framingham Technology Park and 9/90 Crossing, as well as the opportunity for access to Route 9 eastbound. Morning peak traffic volume increased markedly between 1990 and 1997, but midday and evening peak traffic has experienced lower increases, more spread out over a longer period. Similarly, Route 16 traffic is predominantly eastbound in the AM peak period, with a pronounced peak; while westbound traffic, though it does peak during the late afternoon/early evening, is more spread out over several hours, again suggesting a variety of different trip purposes served, as well as greater flexibility among commuters in deciding the time of their trip leaving work.

* * * * *

Additional traffic counts at locations where data are scarce would permit long-term comparisons of growth for key roadways, and would be useful in characterizing congestion as a peak-hour phenomenon at some locations and a chronic daily condition at others. It would be useful to obtain current counts for key north-south roadways, such as Edgell Road and Old Connecticut Path in Framingham, Route 27 in Natick, and Route 16 and Cedar Street in Wellesley, to add to the existing base of information about traffic conditions on Route 9, Route 20, and other well-documented local routes.

3.3. Analysis of Destinations for Selected Links

Several of the count locations described above were selected for analysis to identify the likely destinations of traffic at these locations. This was accomplished by running an assignment of the regional traffic model, with a separate trip table requested as output for each of the links representing these count locations. Only one direction needed to be queried at any site. At six of the twelve locations, the assigned volume calibrated very well with the available traffic count. At the other six, the match was not acceptable for identifying specific destinations with sufficient confidence; however, the breakdown between "internal" and "external" destinations (i.e., inside and outside MetroWest communities) can probably be reasonably inferred even at these locations.

Figures 3-3 and **3-4** illustrate these analyses. They are presented with the caution that the breakdowns shown are derived only from model runs which purport to replicate

count volumes, and which have varying degrees of success at achieving that objective. They are NOT derived from surveys of any kind, which might provide more reliable information but at a cost and scale of effort which is beyond the present study.

The best agreement is observed for the locations along Route 9. At these locations, about half the eastbound traffic over the course of the day is headed for destinations outside MetroWest—primarily the Route 128 corridor and the Boston/Cambridge core. The other half is destined primarily for Framingham, Natick, and, to a lesser extent, Wellesley. Because eastbound traffic on Route 9 peaks during the morning, it is assumed that most eastbound trips are headed to work destinations, both inside and outside MetroWest; however, some of these eastbound trips are home-bound trips in the evening, representing trips from MetroWest work sites to residential areas east of Framingham and Natick.

The westbound traffic on Route 9 at the two locations examined includes only a small component destined for towns outside the MetroWest communities; however, there does not seem to be a great deal of Route 9 traffic at these locations destined for towns west of Westborough and Northborough, or north and south of the study area. It appears that the MassPike is the more efficient route for such traffic; some of this traffic may exit to Route 9 at the 9/90 interchange, but this interchange is west of the count sites for which a breakdown was requested. The largest destinations observed for westbound traffic on Route 9 were Framingham and Natick. These are assumed to represent both trips to residences from Boston/Route 128 job sites, and trips to work sites/shopping opportunities located within these two towns from residences to the east and along Route 128.

The results for Route 16 in Wellesley and Old Connecticut Path in Framingham, also shown on **Figure 3-3**, appear reasonable for these two locations. Route 16 serves a large component of internal Wellesley traffic, but it also provides access to towns located south and west of Wellesley. The one questionable result was the predominance of Marlborough as a destination for southbound traffic on Old Connecticut Path in Framingham. It is likely that some Framingham residents, in particular, may access the Marlborough industrial sites via Route 9 and Framingham Road in Southborough, but the percentage may not be this high.

For the other locations, as mentioned above, there was not sufficient agreement between the counted and assigned volumes to have confidence in detailed results. But **Figure 3-4** at least gives a rough breakdown of internal vs. external destinations at these points, according to the traffic model.

Overall, the results of the selected-link analysis indicate the extent to which traffic in MetroWest has primarily internal destinations. It appears, at least from model results, that by far the largest share of trips have at least one trip end (home, work, recreation or other activity) within MetroWest towns—they are not just "passing through." This makes sense intuitively, particularly for the east-west roadways: "through" trips in the east-west direction probably are more likely to use the MassPike than either Route 9 or Route 20.

More information about the composition of traffic on the major roadways (internal vs. external) would be useful, particularly the north-south roadways, for which the modeling results are less reliable. Selective license plate surveys on key roadways could shed additional light on this question.

3.4. Currently Operating Transit/Paratransit Services

(1) Commuter rail

The Framingham / Worcester commuter rail line is the principal transit route serving commuters from MetroWest destined for downtown Boston, with intermediate stations in Framingham, Natick and Wellesley. Five AM peak-period trips depart from the station in downtown Framingham, including two trips which run express from Framingham / Natick to Boston. **Table 3-3** presents 1996 boarding counts for the stations located in MetroWest.

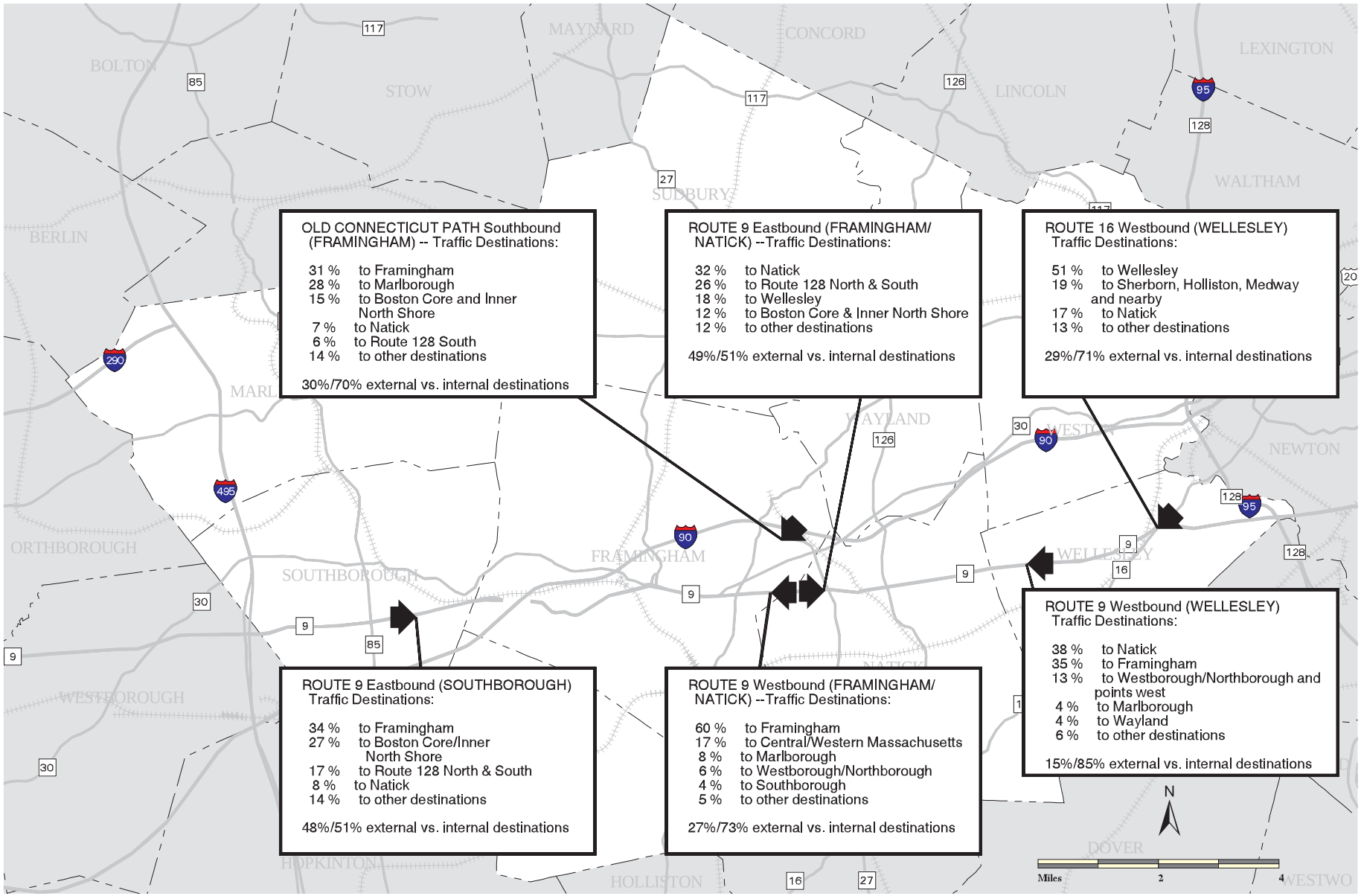
The main limitation of the existing service is lack of sufficient parking. **Table 3-3** also summarizes existing parking availability at MetroWest stations, with an indication of occupancy status. The MBTA is working to remedy this limitation by adding new stations west of Framingham (in Southborough, Ashland, Westborough and Grafton), and by expanding available parking at existing stations, notably in downtown Framingham and Natick Center.

(2) Bus service

Figure 3-5 illustrates the bus transit routes serving the MetroWest area in the Spring of 1999. Current services are operated by several private carriers (Peter Pan, Gulbankian and Cavalier), and by two communities (Framingham and Natick), all with some degree of public subsidy. For the most part, the private carrier services are Boston-directed, but with very limited service (for several, only one round-trip per day) at times that would be useful to commuters.

In the Marlborough area, services are run by Gulbankian and Cavalier Coach. Gulbankian operates routes connecting Hudson-Marlborough to downtown Framingham and Boston via Route 9 and the MassPike, with one trip to each destination during the morning peak period. The Boston service operates via the park & ride lot on Route 9 at California Avenue. There are two return trips from Boston to Hudson (via California Ave.) in the evening peak period; the only evening return trip via the Framingham MBTA station leaves the station at 8:05 PM.

Peter Pan's service currently operates between Worcester and Boston on Route 9, making local stops. There is no peak-period AM bus trip starting in Worcester. Peter Pan does operate an early-morning trip from Shoppers' World, Framingham to downtown Boston.



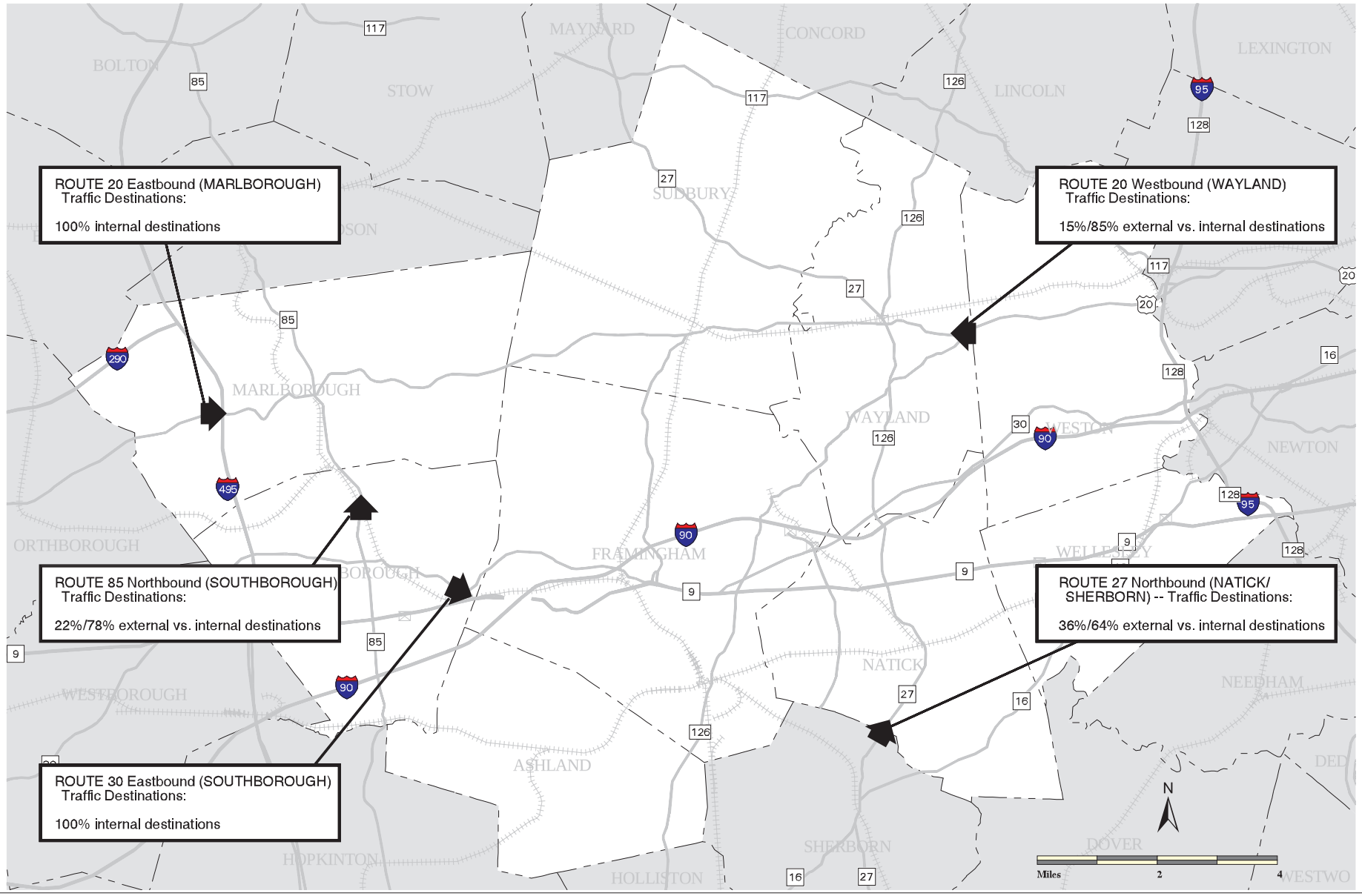
CTPS
MetroWest Subregional Area Study

Link Location

NOTE: based on CTPS model runs only

Figure 3-3
Destinations of Traffic Flows, Selected Links (1 of 2)

July 11, 2000 pl_mw-08sel.aml



CTPS
MetroWest Subregional Area Study

Link Location

NOTE: based on CTPS model runs only

Figure 3-4
Destinations of Traffic Flows, Selected Links (2 of 2)

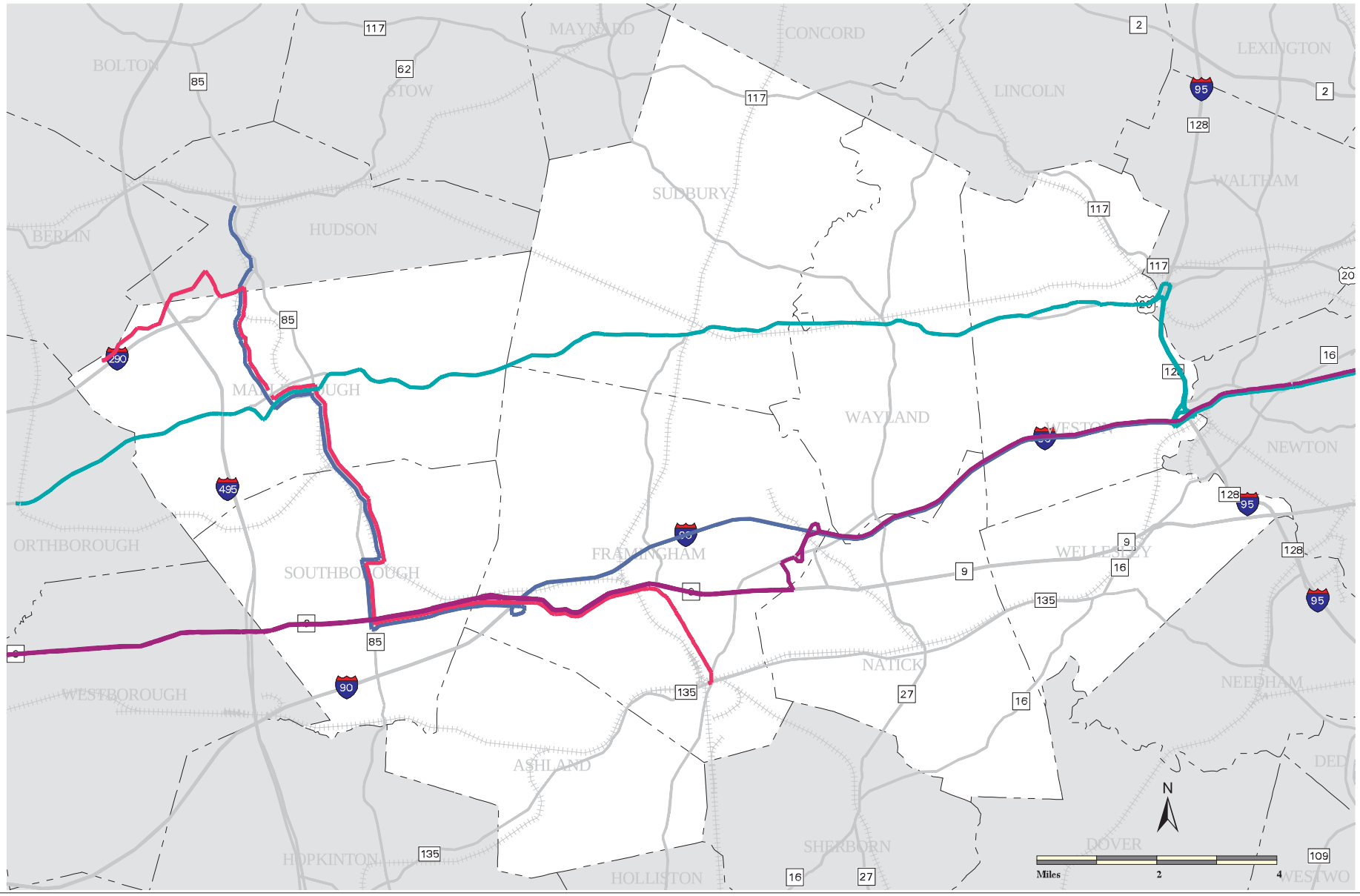
TABLE 3-3
MetroWest Commuter Rail Ridership and Parking

Line / Station	Daily Boardings (1996)	Parking Spaces in Station Vicinity*	Parking Lot Occupancy
Framingham Line			
Framingham	1,337	540 (incl 120 at stn)**	Full
West Natick	1,011	163 at stn	Full
Natick	694	231**	Full
Wellesley Square	711	245 (incl 21 at stn)	Full
Wellesley Hills	482	69 (incl 51 at stn)	Full
Wellesley Farms	489	200	Full
Fitchburg Line			
Silver Hill	17	6	Underutilized
Hastings	31	16	Full
Kendall Green	105	25	Full

*including spaces within station parking lot, as well as other nearby spaces in lots or on the street, frequently or typically used by rail commuters
**being moved, expanded and / or rebuilt as part of current Worcester Branch extension program

Cavalier Coach is currently operating one peak-period trip per day to and from Boston from Northborough and Marlborough via Route 20. Also, there is one trip per day starting from South Station in the AM peak period and arriving in the Marlborough industrial area at 8:20-8:25 AM, with a corresponding reverse trip leaving Marlborough for Boston at 5:30 PM.

Of these services, Gulbankian's Hudson-to-Boston service carries the greatest number of average daily passengers (over 90), while the Peter Pan and Cavalier services carry fewer than 40 average daily passengers. All these routes operate with some level of MBTA subsidy. The highest per-passenger subsidy is paid for the Peter Pan Route 9 service between Worcester and Boston, service which is likely to be changed under new service contracts being negotiated in Summer 1999. Under the revised operation, Peter Pan will continue to operate only express service between Shoppers' World and downtown Boston, using the MassPike.



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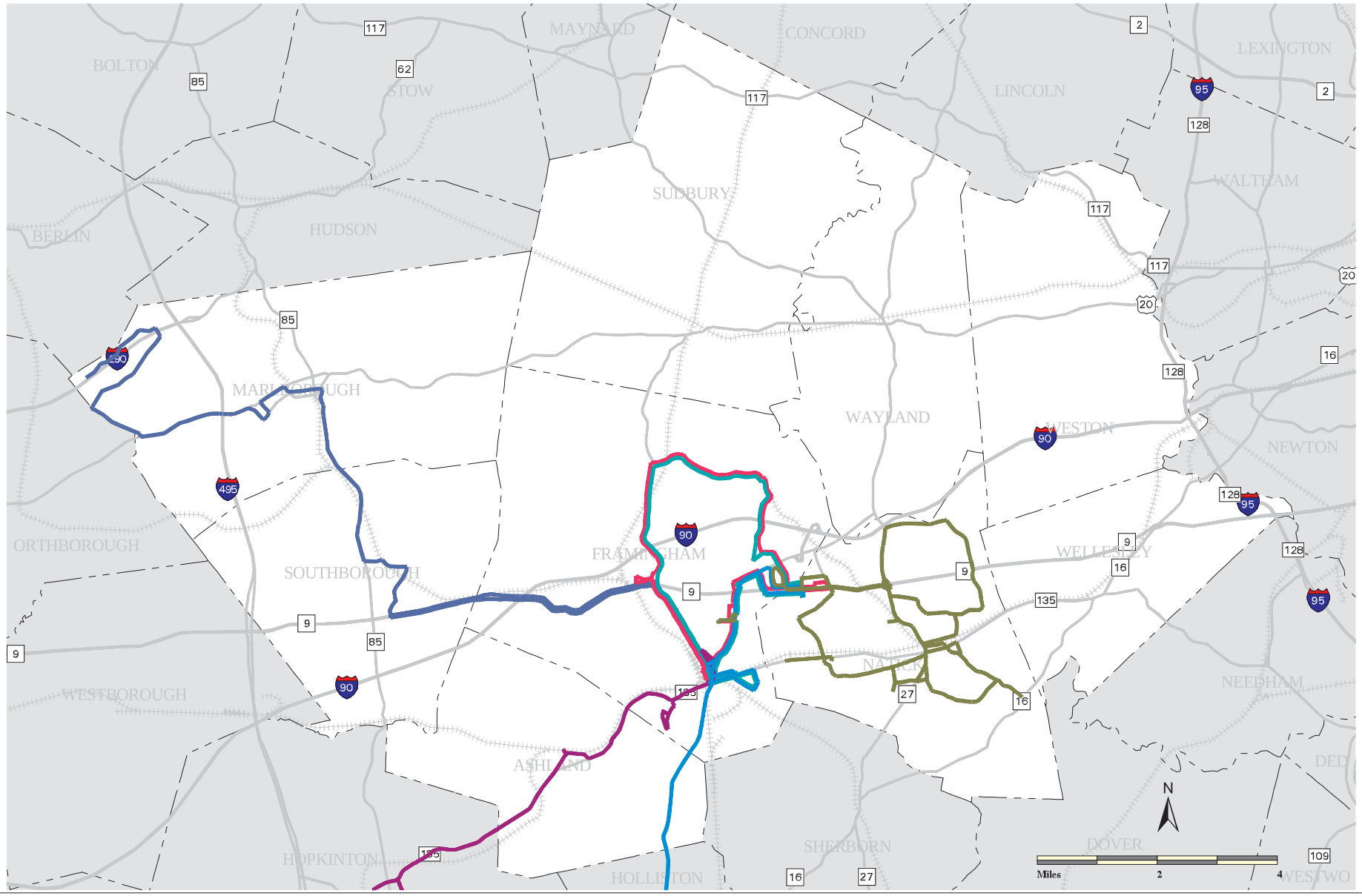
Gulbankian, Hudson-Boston
Gulbankian, Framingham-Solomon Pond Mall (Saturday only)
Cavalier Coach, Marlborough-Boston
Peter Pan, Worcester-Boston

(Source: route maps and schedules, private carriers)

Figure 3-5
MetroWest Transit Routes: Private Carriers



CTPS
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Lift 2
Lift 3
Lift 5
Lift 6
Lift 7
Natick Neighborhood Bus (incl. request stops)

(Source: route maps and schedules, town bus services)

Figure 3-6
MetroWest Transit Routes: The Lift and Natick Neighborhood Bus

July 11, 2000 pl_mw-09lif.aml

The two town-operated services are Framingham's LIFT and the Natick Neighborhood Bus. The LIFT has been operating for many years, and currently provides local service, usually on hourly or two-hour headways, on five routes which all converge at Concord / Howard Streets in downtown Framingham (shown on **Figure 3-6**). It serves a local commuter market, as well as trips to the malls on Route 9 and the local medical centers, with one route which serves the Framingham Technology Center at the 9 / 90 interchange. Its patrons tend to be relatively low-income wage-earners, retired persons, and others with limited transportation alternatives for shopping and recreational as well as commuter trips; and the LIFT tailors its routes to serve the needs of these markets. The Town of Framingham does not own the vehicles, but contracts with a local provider. Individual LIFT routes carry on the order of 40-120 passengers per day.

Natick's service (also shown on **Figure 3-6**) is operated with two town-owned buses, which meet primarily social-service needs, such as elderly transport to local medical centers and shopping centers. This service is partly demand-responsive: it serves some stops identified in its schedule only upon telephoned request.

Finally, Massport operates express bus service to Logan Airport from a location just off Route 30 in Framingham, close to the MassPike interchange. This service has been very successful since its inception; like commuter rail service in this region, it is currently constrained by the lack of sufficient parking to meet demand. Massport is currently attempting to identify opportunities for expanding parking which will meet with Framingham's approval.

(3) Shuttles

In addition to rail and bus transit, shuttle services providing connections to transit are operated by the MetroWest TMA, by some employers for their own employees, and by area colleges for their employees and students. Both Staples and Bose have shuttle buses for their employees, connecting with the park & ride lot on Route 9 at California Avenue. A shuttle-type bus formerly connected the Natick Center commuter rail station with Natick Labs and several major employers located in the Speen Street / Old Connecticut Path area (Boston Scientific, TJX and Meditech). This service was discontinued recently because no long-term funding source was found to replace the expiring public subsidy and private support provided by TJX and Boston Scientific.

Previous investigations of employer shuttles suggest that the most successful applications of employer shuttle services occur: (a) as a result of public / private cooperation in coordinating public transit services and schedules with privately operated vans and buses; (b) with strong institutional and financial support from employers; (c) when an effective marketing program is established for shuttle services; and (d) when the "geography is right." This latter requirement includes: frequent commuter-rail or express bus service in a congested highway corridor; a seamless, low-cost transfer to a shuttle bus; and a direct route to major employment concentrations within a 20-minute (maximum) bus ride.[4]

[4] Minerva, Victor, et al., "Employer Shuttles—Concepts and Case Studies," *Transportation Research Record 1557*, Transportation Research Board, 1996.

The potential for expanding such shuttle services in MetroWest is also limited by the availability of plentiful free employee parking, and employer resistance to paying for such services without any obvious direct benefit to themselves. A 1992 study of parking requirements associated with new developments in MetroWest towns[5] noted that these requirements exceeded industry average and maximum parking generation for non-residential land use types. These requirements are *minima*, rather than *maxima*, reflecting the traditional local concern that inadequate numbers of long-term employee parking result in commuter usurpation of nearby short-term or residential parking. Employer-provided financial support for shuttle services, like the Boston Scientific/TJX subsidies, have tended to be short-lived subsidy arrangements. Only at locations where an employer is motivated by self-interest to invest permanently in such services—either to avoid having to build structured parking, or to attract employees from special markets where shuttle services are seen as a recruitment aid, or as a precondition of receiving development approvals—are they likely to be made available and sustained over time.

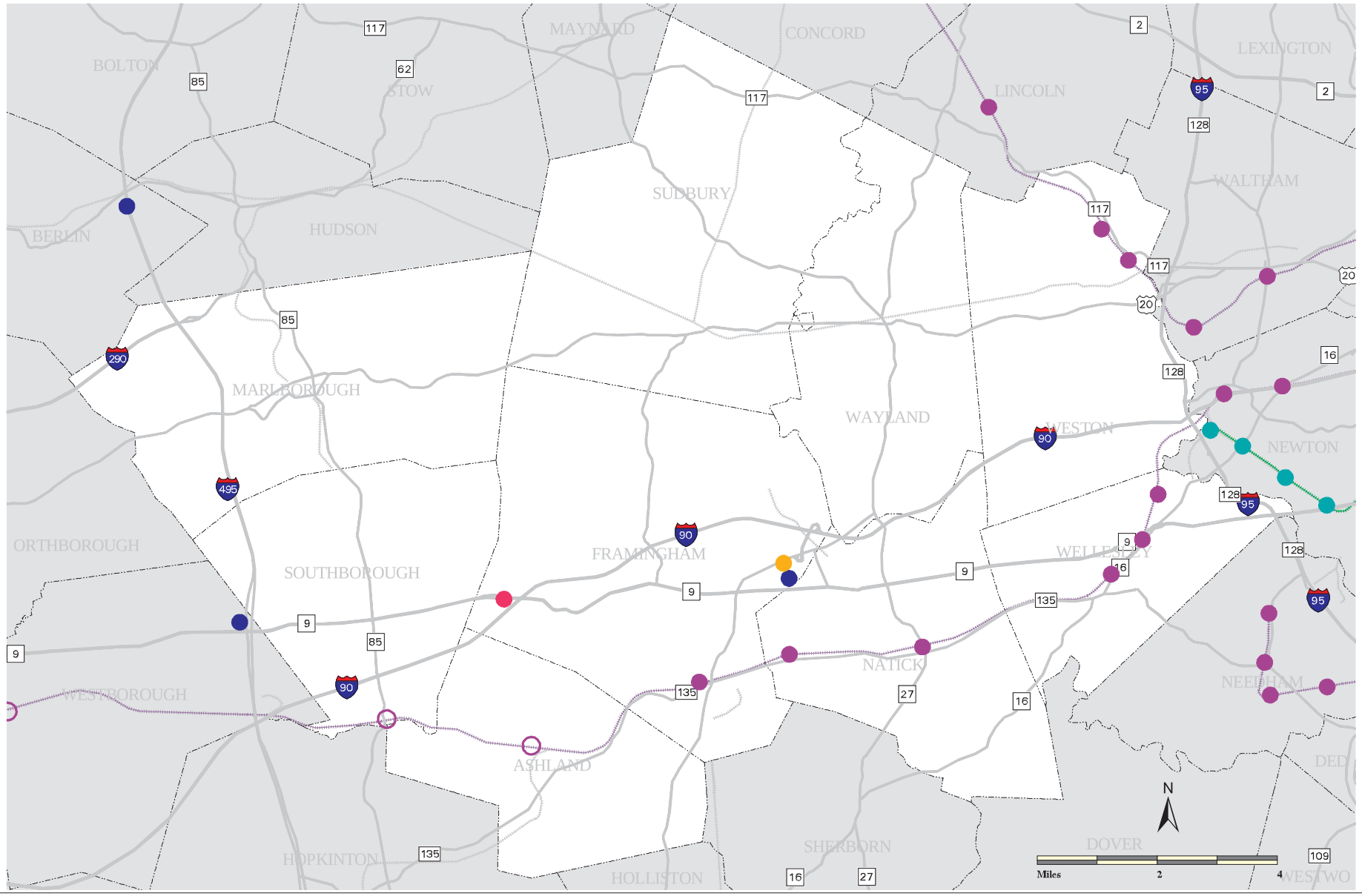
Of the local colleges, Massachusetts Bay Community College operates a student shuttle connecting with the MBTA's Riverside Station, with frequent service during the academic year. Framingham State College operates a shuttle bus connecting the main campus with its remote parking lots, but without any direct connections to any transit station. There is a bus link between Wellesley College and M.I.T. in Cambridge, operated by Wellesley, which stops at the MBTA's Woodland station; the College is planning to expand this service in Summer 1999.

(4) Park & ride lots

As suggested above, very successful park & ride lots are in operation at MetroWest commuter rail stations and at the Logan Express bus stop (**Figure 3-7**). The issue at these locations is how to accommodate additional parking demand, and efforts are underway by the MBTA, Massport, and local officials to provide expanded parking opportunities at these sites.

Less successful park & ride lots are those at Shoppers World and California Avenue, both in Framingham. The Shoppers World lot, leased by MassHighway from the adjacent movie theater, was created as a formal replacement of an informal parking arrangement that existed in one corner of the old Shoppers World parking lot before that retail complex was rebuilt. It is underutilized for a number of reasons, including very limited and inconveniently scheduled bus service, poor visibility of the lot from Route 9, and, most important, the threat that parked cars will be towed at 6:00 PM to accommodate movie theater parking. The California Avenue lot is operated by the Massachusetts Turnpike Authority. Route 9 buses operated by Peter Pan also stop at this lot on the inbound trip; currently, there is no safe way to allow pedestrians to cross Route 9 on the outbound trip to return to their cars, and no way for buses to turn into and out of the lot on the outbound trip.

[5] MetroWest Growth Management Committee, "Comparative Study of Parking Requirements in the MetroWest Subregion," November 30, 1992.



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- MBTA Commuter Rail
- MBTA Proposed
- MBTA Green Line
- MassHighway
- MassPort (Logan Express)
- MassTurnpike

(NOTE: parking at some locations owned by town or private entity)

Figure 3-7
MetroWest Area Park/Ride Lots

July 11, 2000 pl_mw-35pkr.aml

CTPS is currently investigating strategies which might increase the attractiveness of MassHighway park & ride sites to commuters, including the Shoppers World lot. Pending changes to Peter Pan's Route 9 service may make that service, and therefore the park & ride option at this lot, somewhat more attractive. The time restrictions on parking at the Shoppers World lot represent a more significant problem, requiring renegotiated agreements between MassHighway and the theater owner, or ultimately relocation of the lot.

The California Avenue median break and signal replacement, scheduled to be built by MassHighway in 1999, will be designed to allow left turns from Route 9 Eastbound into California Avenue. Local requests have been made for a pedestrian crossing to the park & ride lot at this location, to allow commuters returning home on westbound buses to access their vehicles safely. At present, it appears that such a pedestrian crossing is not likely to be provided; in addition, the intention currently is to prohibit westbound left turns from Route 9 at this location for vehicles, including buses. A relocated lot on the north side of Route 9, possibly within the Industrial Park area, could conceivably offer improved service and safer operation to commuters, by eliminating the need for either a permitted westbound left-turn into the current lot, *or* a new pedestrian crossing at this complex location.

4. CURRENT INITIATIVES AT IDENTIFIED CONGESTED AREAS

Table 16 of the 1997 Congestion Management System report[6] summarized the congested locations identified through monitoring activities that year. These are shown on **Figure 4-1**. Many of these locations are already being addressed through state and/or local initiatives which address, in one way or another, problems experienced there. In some cases, the prescribed courses of action are not designed to reduce congestion, but may (in the short term, at least) actually increase delays—e.g., by increasing the number of signals on an arterial, or reducing the capacity of roadways to achieve some measure of traffic calming or enhancement. At such locations, where other values have been balanced against the congestion reduction benefits (particularly benefits associated with increases in road capacity), the outcomes typically represent local policy choices which must be respected.

This section addresses each congested location identified in Table 16 of the CMS report, and identifies any recent initiatives, or any currently being undertaken, at particular locations.

(1) Route 135 – congested segments in all four communities; LOS E/F between Weston Road and Route 16, Wellesley

Route 135 in both Framingham and Natick is currently being designed for reconstruction, and will be turned over to the towns once rebuilt. These projects will include

[6] Central Transportation Planning Staff, *Mobility in the Boston Region: The Congestion Management System Annual Report for 1997,* by Jim Gallagher *et al.*, February 1998.

minor modifications at intersections, but no significant addition to existing capacity. No activities or projects are currently in planning or design for Route 135 in Ashland or Wellesley, to our knowledge. It is worth noting that the section identified as congested in Wellesley includes the town center and one of two principal business/shopping areas in town, with frequent signals, on-street parking, and numerous pedestrian crosswalks. There is very limited potential here for reducing congestion, nor is this likely to be desirable to town residents if it implies increased vehicular speeds.

(2) Route 16 West corridor in Wellesley, especially at Route 9 and Route 135

Similar to Route 135 in Wellesley, Route 16 at these two locations traverses built-up local business areas, with frequent signals, on-street parking, and crosswalks. Route 16 in this section was recently reconstructed at the town's initiative, using primarily Chapter 90 funding. The intent of the reconstruction was to enhance the "village"-like, pedestrian-friendly quality of this section of Washington Street. Local preference appears to be to maintain the slower-speed character of Washington Street as it currently exists.

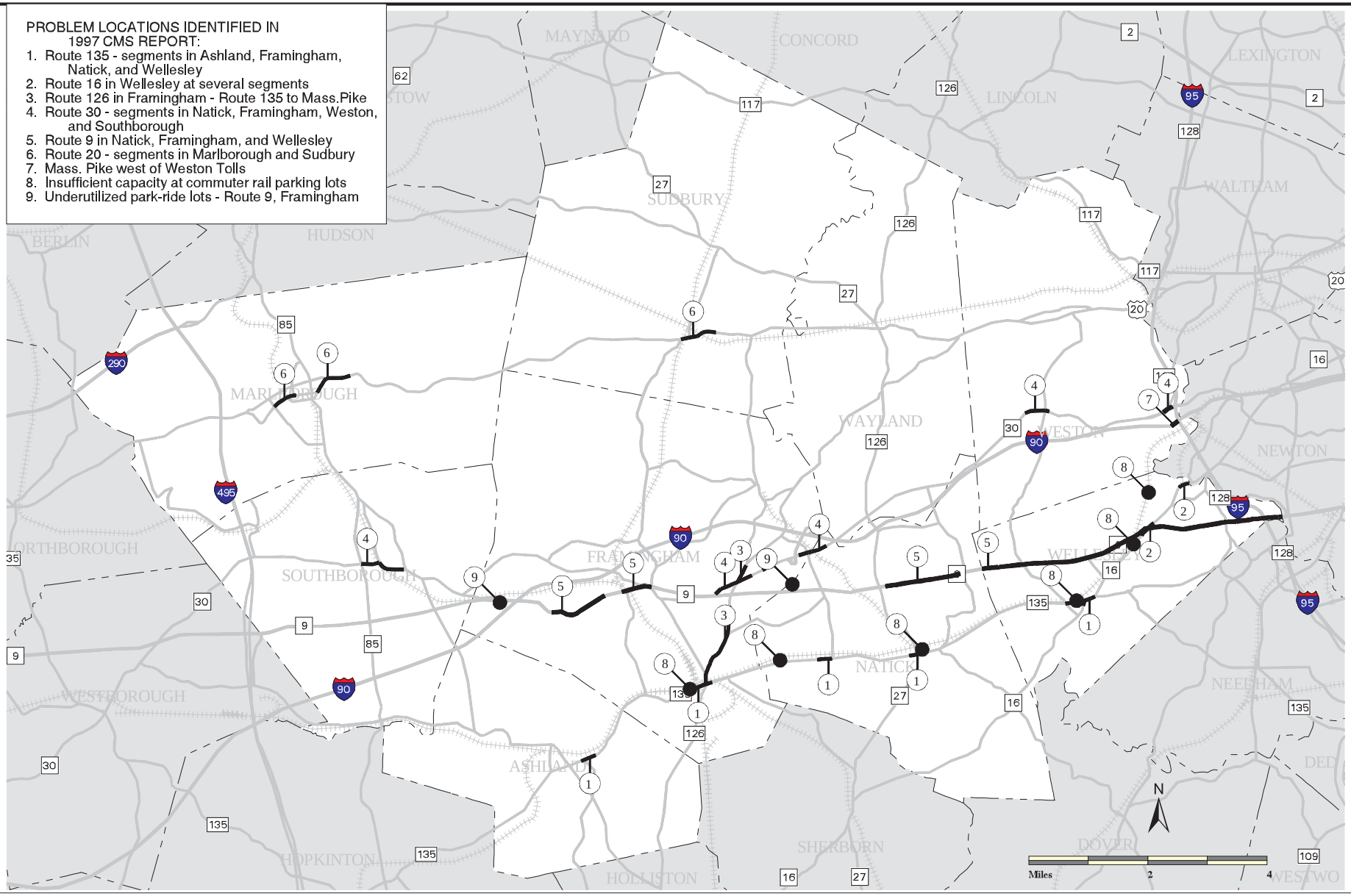
(3) Six segments on Route 126 in Framingham, between Route 135 and the Mass. Turnpike

Several planning studies and projects are currently underway to address observed problems on Route 126 in Framingham. These include:

- MassHighway initiatives to redesign and reconstruct the existing substandard interchange at Route 9/Route 126 and the Route 126/Route 30 intersection.
- Town of Framingham initiatives for downtown streetscape improvements, paid for in part with ISTEA enhancement funds.
- Town's desired upgrades to traffic signals at six locations, several of which are located in this section of Route 126.
- Town-sponsored feasibility study of grade-separating Route 126 at railroad tracks.

The last of these is clearly a long-term project, which can not be expected to provide benefits within current construction horizons. The other projects are listed in the current TIP: the Route 126/Route 30 intersection upgrade is currently programmed for FY 1999, and the Route 9/Route 126 interchange upgrade is in design.

(4) Locations on Route 30 – (a) the section between Speen Street in Natick and Route 9 in Framingham; (b) the area near the Wellesley Street intersection in Weston; and (c) the section between Framingham Road and Route 85 in Southborough



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(Source: "Mobility in the Boston Region: The Congestion Management System Annual Report for 1997," Table 16)

Figure 4-1
Congested Locations Identified in 1997 CMS Report

July 11, 2000 pl_mw-32cmp.aml

(a) Part of the Framingham section of Route 30 (between the Mass. Turnpike interchange and Caldor Road) in Framingham was redesigned and reconstructed in the early 1990s. The redesign included widening, installation of new coordinated signals, left-turn lanes at the mall entrances, and other improvements. The remaining sections include the Speen Street intersection and its eastbound approach (reconstruction advertised, to be completed in 1999), the area between Caldor Road and Route 126 (improvements to the Route 126/Route 30 intersection already programmed, as mentioned in (3) above), and the section east of Route 126.

To our knowledge, no improvements are currently in planning or design for the section east of Route 126. This section of Route 30 serves mainly to provide local access for abutting businesses and residents. The most problematic aspect of this section is its intersection with Route 9, an awkward and difficult intersection which may merit consideration for redesign or other improvement.

(b) The section in Weston is in the vicinity of the signalized intersection with Wellesley Street. To a large extent, delay experienced here is signalized intersection delay, which might be improved through intersection redesign. This is one of five locations currently being examined as part of CTPS's ongoing signalized intersection study. Recommendations for improvements are anticipated shortly.

(c) The section of Route 30 between Framingham Road and Route 85 in Southborough, particularly west of the left turn at Newton Street, is a narrow local road through the small business district which effectively serves as Southborough's business area. Buildings are placed close to the road with little room for adding roadway capacity, even if this were likely to be desirable to Southborough residents. The changing grades and horizontal curvature of the road here likewise encourage slow passage. It is not clear that slow travel speeds here represent a congestion problem from the point of view of local residents.

(5) Route 9 at several locations: (a) Route 27 to Oak Street, Natick; (b) Temple Street to Country Club Lane, Framingham; (c) entire Wellesley corridor

(a) The section of Route 9 through Natick has been under investigation for some time. The Route 27 interchange is an old-fashioned, substandard interchange similar to the Route 9/Route 126 interchange in Framingham. Currently, MassHighway plans to replace the bridge only. There may be justification for considering additional improvements at this location. The section of Route 9 which abuts the Apple Hill development currently has no median break. Developers of the expanded Apple Hill have sought MassHighway approval for modifications at this location, including a median break and installation of a three-phase signal, requests which MassHighway has thus far denied. Finally, the complex intersection at Route 9 and Oak Street is a key locus of delay in this corridor. MassHighway's District 3 Office is evaluating several design alternatives which would upgrade the Oak Street intersection.

(b) The intersection of Temple Street with Route 9 is a complex signalized intersection which accommodates multiple heavy traffic movements. No plans or proposals are

currently active at this location, to our knowledge, although the Framingham Planning Board recently paid for a reconnaissance study to investigate what improvements might be possible at that location. The Country Club Lane intersection is a signalized intersection of a relatively minor street with Route 9. The eastbound U-turn lane accommodates vehicles which miss the opportunity to exit Route 9 at Crossing Boulevard, as well as some vehicles destined for the 9/90 interchange of the MassPike and the California Avenue entrance to the Framingham Technology Park. Improvements to the Route 9/Country Club Lane intersection are included as part of the mitigation for the "9/90 Crossing" project, and are currently in Final Design. They include widening of Country Club Lane itself, as well as signal improvements.

(c) Route 9 within Wellesley is currently the focus of a corridor study designed to evaluate a range of possible improvements to alleviate congestion.

(6) Segments of Route 20 in Marlborough and Sudbury

The portion of Route 20 through downtown Marlborough traverses a built-up business area where relatively slow speeds may be regarded as desirable because of pedestrian movements, parking activity, and frequent driveways and signalized intersections. Segments of Route 20 close to the downtown business district are programmed in the current TIP for reconstruction, including widening.

In Sudbury, a project to upgrade signals at the Route 20/Concord Road intersection has been advertised. Additional review may be warranted at this location to determine whether other improvements can be recommended to reduce delays.

(7) MassPike west of Weston tolls

The problem identified at this location results from delays at the eastbound toll booths. Efforts to alleviate queuing, through the installation of "FAST LANES" which use automated transponder technology for toll collection, have had only limited success, because of the reduced numbers of toll booths available for vehicles not equipped with transponders. Use of the transponder technology is expected to become more widespread by regular Turnpike travelers, and should result in an overall reduction of delays.

(8) Commuter rail park & ride lots with inadequate capacity

The 1997 CMS Report identified overcrowded conditions at the MBTA commuter rail parking lots at Framingham, Natick and Wellesley. The principal mechanism for addressing this problem is the ongoing Worcester/Framingham line improvement project, which will include new commuter rail stations with parking in several towns west of Framingham, thereby intercepting upstream some of the parking demand at the congested lots. In addition, efforts are underway to expand existing parking at both the Framingham and Natick Center commuter rail stations.

(9) Underutilized MassHighway and MassPike Framingham lots

CTPS is currently undertaking a study of existing MassHighway park & ride lots, including the lot at Shoppers World. This lot, and the California Avenue lot, were discussed in detail in Section 3.4(4) above.

* * * * *

In addition to these activities, which relate to locations specifically identified in the 1997 CMS report, other studies and initiatives are currently in planning or design to address congestion and safety problems areawide. Projects which are currently listed in the Transportation Improvement Program (TIP) are summarized in **Table 4-1** and **Figure 4-2,** while other pending actions resulting from private developer or local town initiative are shown in **Figure 4-3.** CTPS is also engaged in several studies aimed at evaluating and recommending transportation improvements involving different modes of travel within MetroWest: these are shown on **Figure 4-4**. **Tables C-1** through **C-9,** found in **Appendix C**, summarize ongoing activities and studies by town.

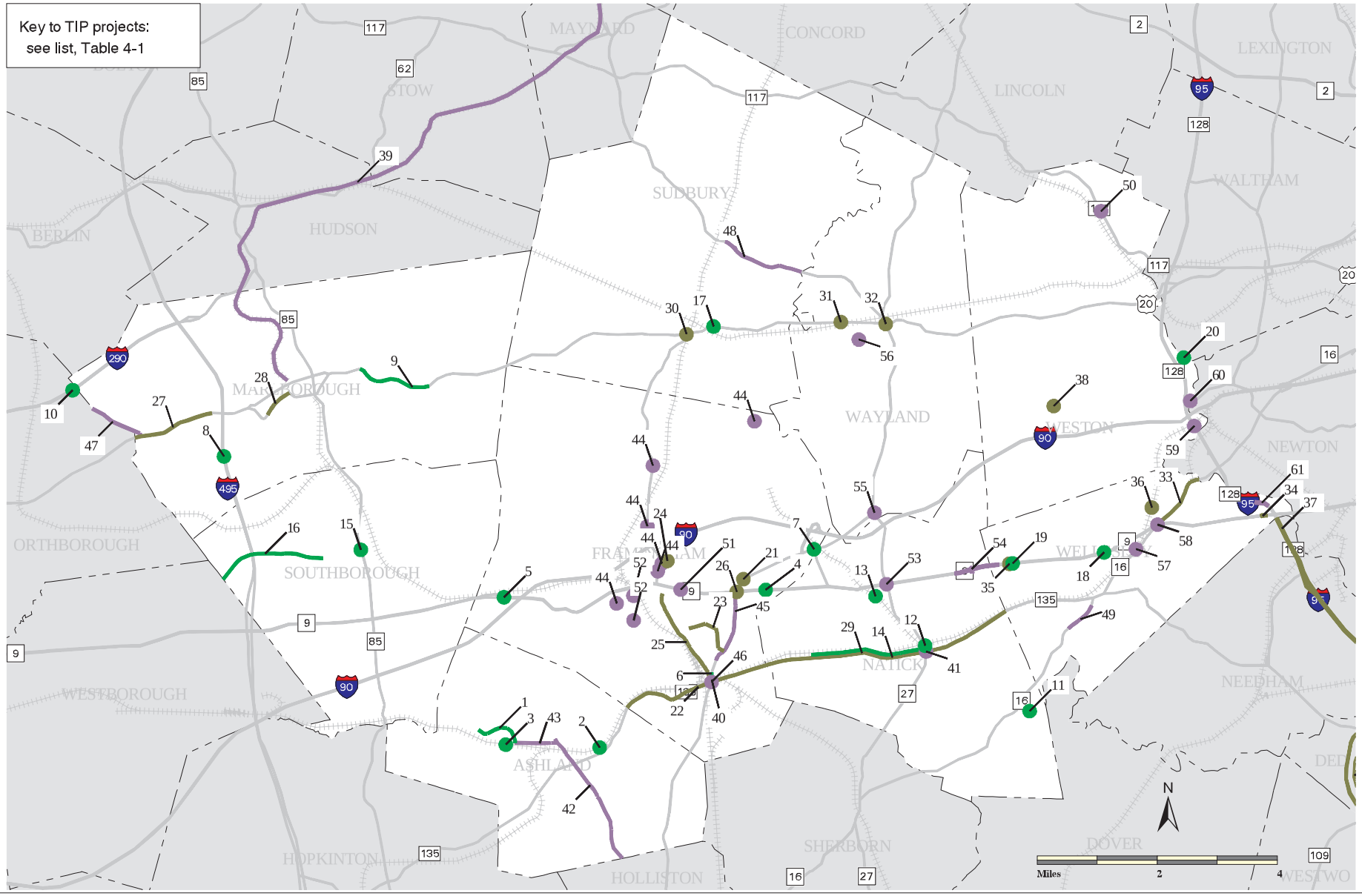
TABLE 4-1
Current TIP Projects by Status, Summer 1999*

KEY NUMBER (see **FIG 4-2**)	TOWN	PROJECT	TIP ID NO.
A. Projects Already Constructed or Advertised			
1	Ashland	Cordaville Rd. repaving	601875
2	Ashland	Fountain St. Bridge replacement	26703
3	Ashland	High St. Bridge replacement	160060
4	Framingham	Rte. 9-Caldor Rd. intersection improvement	600504
5	Framingham	Rte. 9-California Ave. median break	601662
6	Framingham	Downtown Streetscape, Phase 1	--
7	Framingham / Natick	Rte. 30-Speen St. intersection reconstruction	110952
8	Marlborough	I-495 Interchange construction	63615
9	Marlborough	Rte. 20 (East) reconstruction	600630
10	Marlborough / Northborough	Interstate 290-Solomon Pond Rd. intersection	601063
11	Natick	Pleasant St. Bridge rehabilitation	601266
12	Natick	Dennis Moran Park	--
13	Natick	Loker St. Bridge reconstruction (Conrail)	39360
14	Natick	Rte. 135, Phase 1 (Bicycle & Pedestrian Improvements)	--
15	Southborough	Rte. 85 traffic signal (St. Mark School)	602001
16	Southborough	Rte. 30 (Main St.) resurfacing	601621
17	Sudbury	Rte. 20-Concord Rd. signal upgrade	100801
18	Wellesley	Rte. 9 resurfacing (one section)	601800
19	Wellesley	Rte. 9-Lexington Rd. safety improvements	601620
20	Waltham / Weston	South St. (River Rd.) Bridge replacement	130375
B. Programmed in Current TIP			
21	Framingham	Rte. 126-Rte. 30 intersection improvements	86450
22	Framingham	Rte. 135 (Waverly St.) reconstruction	600577
23	Framingham	Warren Rd. / Dennison Ave. reconstruction	601311
24	Framingham	Central St. Bridge replacement	602839
25	Framingham	Franklin St. reconstruction	602046
26	Framingham	Rte. 126 Bridge over Rte. 9	602624
27	Marlborough	Rte. 20 (Boston Post Rd.) widening / reconstruction	601133

*Note: reflects FY 2000-2005 TIP draft document currently in circulation (August 1999) but not yet approved by Boston MPO.

Table 4-1 (cont'd) – Current TIP Projects by Status, Summer 1999

28	Marlborough	Rte. 20 (W. Main St.) reconstruction	600428
29	Natick	Rte. 135 reconstruction	600573
30	Sudbury	Rte. 20-Nobscot Rd. geometric improvements	601578
31	Wayland	Rte. 20 Bridge rehab (over Sudbury River)	105121
32	Wayland	Rte. 20-Rte. 126/27 signal improvements	105122
33	Wellesley	Rte. 16 (Washington St.) reconstruction	600712
34	Wellesley	Rte. 9 (Worcester St.) reconstruction	602616
35	Wellesley	Rte. 9 Drainage improvements (Boulder Brook)	125298
36	Wellesley	Woodlawn Ave. Bridge reconstruction	601665
37	Randolph to Wellesley	Rte. 128 Add-a-Lane	86920
38	Weston	Rt. 30-Wellesley St. safety improvement	602000
C. Enhancement Project			
39	Acton/Hudson/Marlborough/Maynard/Stow	Assabet Rail Trail	--
40	Framingham	Downtown streetscape, Phase 2	--
41	Natick	Natick Center improvements	--
D. Appendix H – Local List			
42	Ashland	Main St. (Prospect St.) resurfacing	602065
43	Ashland	Pleasant St. resurfacing	602064
44	Framingham	Traffic Signal installation/upgrade at 6 Locations	602038
45	Framingham	Route 126 (Hartford St to Lincoln St)	--
46	Framingham	Route 135/Route 126	--
47	Marlborough/Northborough	Boundary St. reconstruction	6870
48	Sudbury	Old Sudbury Rd. geometric improvements	--
49	Wellesley	Rte. 16 (Washington St.) reconstruction	602087
50	Weston	Rte. 117 (North Ave.) resurfacing (one section)	601999
E. Appendix H – State List			
51	Framingham	Rte. 9 Bridge replacement (Sudbury River)	602522
52	Framingham	Winter St., Two Bridges (over Sudbury River)	602464
53	Natick	Rte. 27 Bridge replacement (over Rte. 9)	602777



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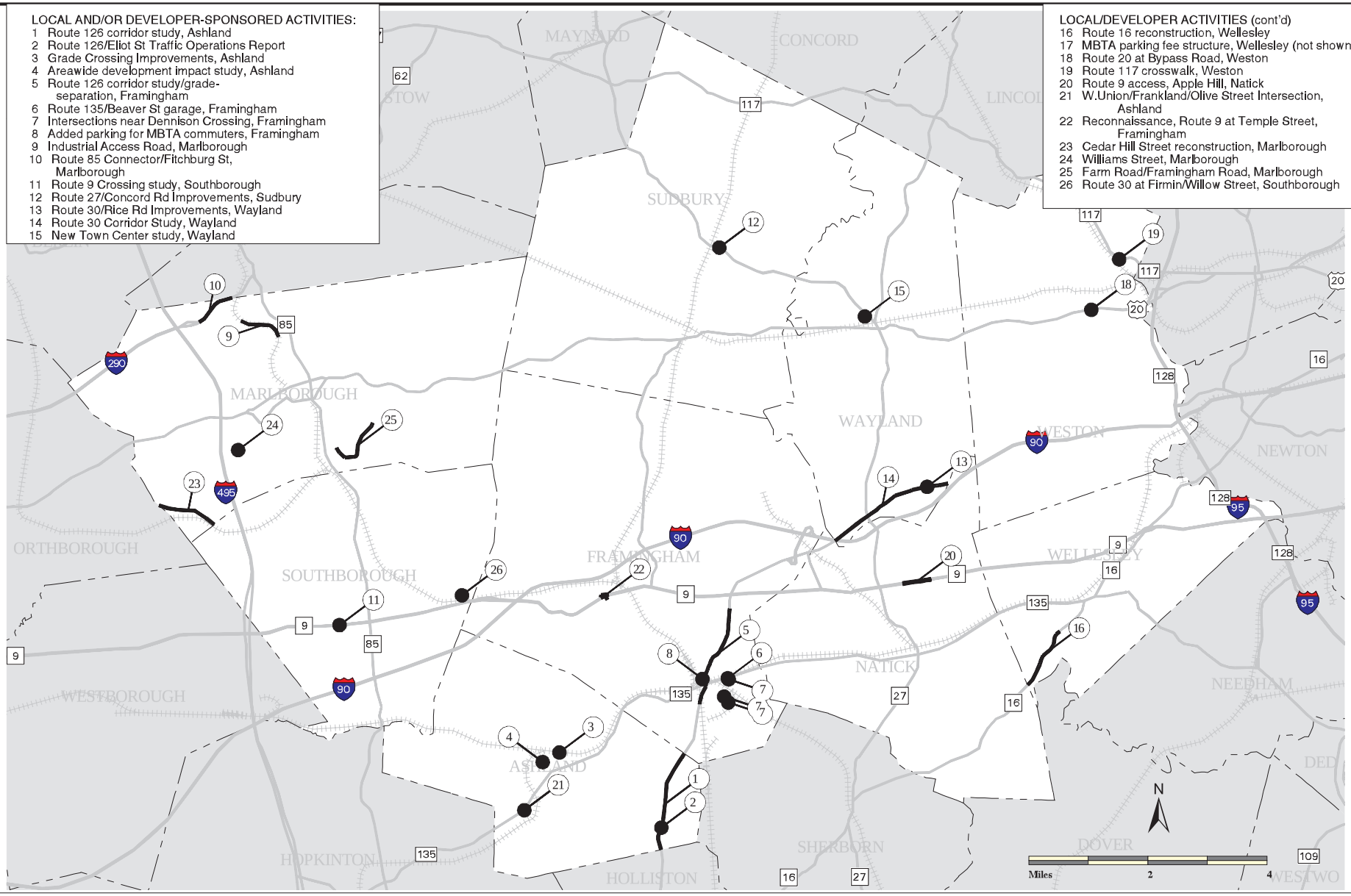
Projects

- **Advertised or completed**
- **Programmed in TIP**
- **Appendix H or Enhancement Project**

Figure 4-2
Projects in 2000-2005 (Draft) TIP, by Status

Table 4-1 (cont'd) – Current TIP Projects by Status, Summer 1999

54	Natick / Wellesley	Rte. 9 improvements (Oak St / Overbrook Drive)	601586
55	Wayland	Rte. 27-Rte. 30 geometric improvements	601579
56	Wayland	Pelham Island Rd. Bridge replacement	602723
57	Wellesley	Rockland St. Bridge replacement (over Conrail)	600776
58	Wellesley	Rte. 16 Bridge rehabilitation (over Rte. 9)	94762
59	Weston	Recreation Rd. Bridge replacement	602534
60	Newton / Weston	Rte. 30 Bridge deck rehabilitation	110980
61	Newton / Wellesley	I-95 noise barriers	602840



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NOTE: Partial list only—constantly being revised

Figure 4-3
Local and/or Developer-Sponsored Studies & Projects

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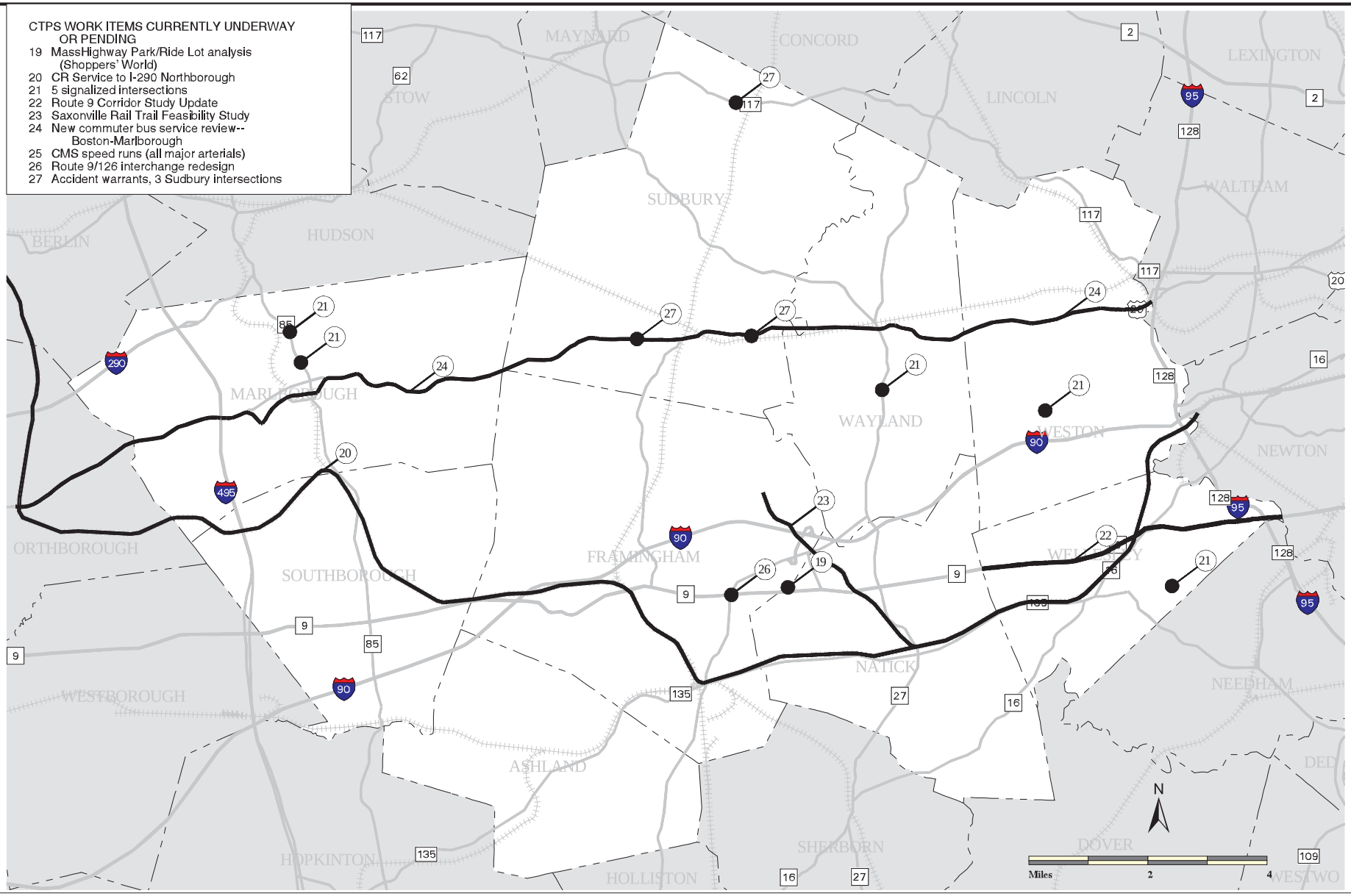

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Figure 4-4
CTPS Studies in MetroWest Currently Underway or Pending

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5. NEXT STEPS

In summary, planning activities or active design/construction projects are currently underway to address problems at many of the locations identified in the 1997 CMS report. Other locations from the report, at which no activity is currently underway but which may benefit from additional study and recommendations, include the following:

Route 30 at its intersection with Route 9, Framingham
Route 27 interchange at Route 9, Natick
Intersection of Route 20 and Concord Road, Sudbury

In addition to the locations identified in the CMS report, the MetroWest Growth Management Committee and the town planners from each MetroWest town were asked about additional locations exhibiting congestion, which could benefit from planning study attention. The results of these discussions with town planners are summarized in **Figure 5-1** and **Table 5-1.** This table is an initial list of planning tasks aimed at evaluating specific locations or specific problems not otherwise being addressed. It is anticipated that this will not be a one-time list, but will be updated periodically as part of continued Congestion Management System efforts. There is considerable overlap between the problem areas enumerated by town planners and others (**Table 5-1**), and the congested locations observed during monitoring activities and catalogued in the CMS report.

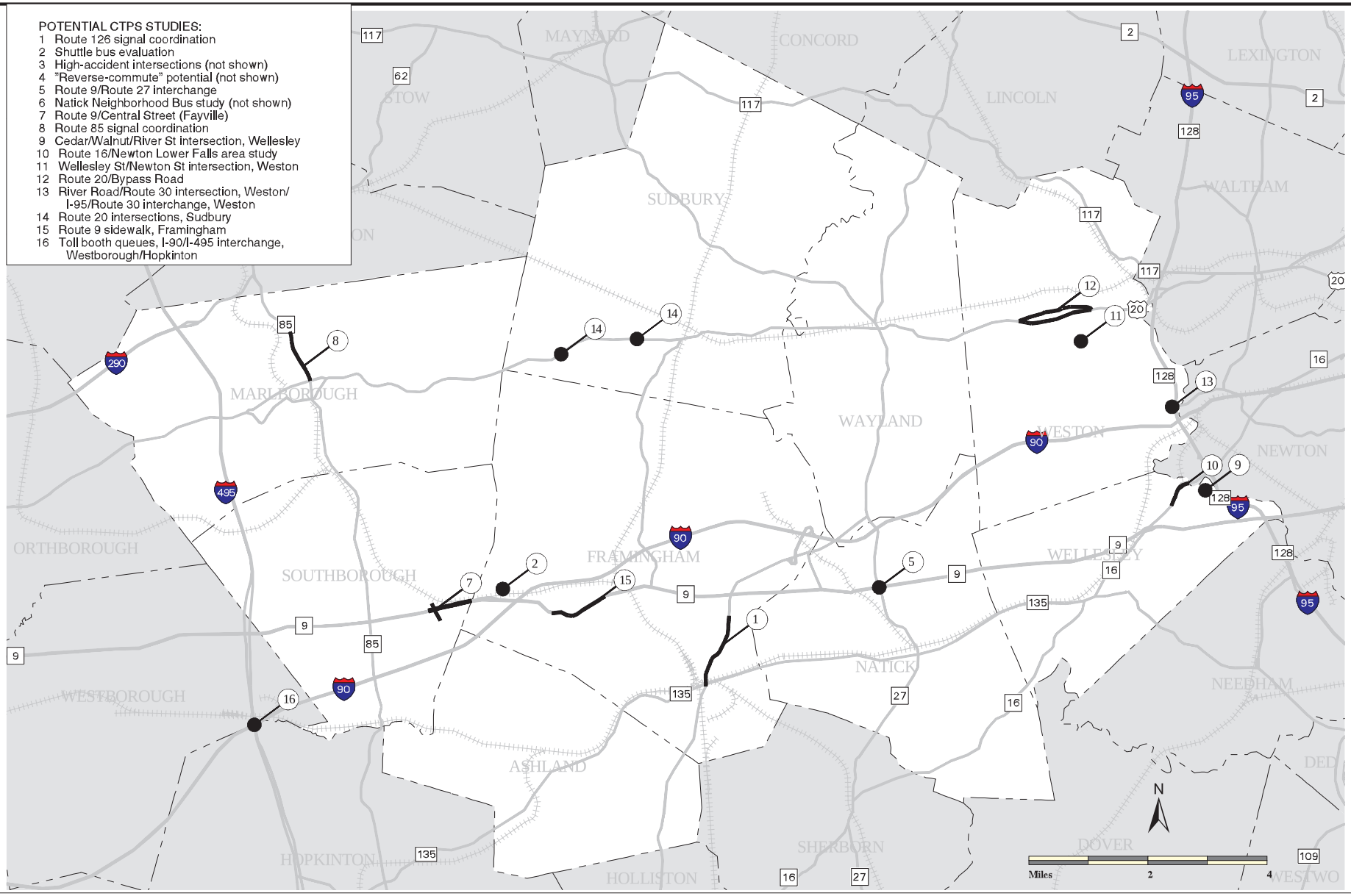
Under Phase II of the study, a subset of the issues/locations identified in **Table 5-1** will be investigated, and possible solutions or approaches outlined. Outstanding issues remaining on the list, and additional issues or problem locations identified in continuing outreach efforts to MetroWest town planners, town engineers, and the Growth Management Committee, will be addressed in subsequent study efforts.

Criteria for determining whether CTPS involvement is appropriate to address a particular issue or problem location include the following:

- The issue or problem is congestion-related, and conceptual solution strategies would meet local needs and desires.
- The issue or problem can be addressed effectively by applying analytical and planning tools available to CTPS.
- The issue or problem can be fit into the CTPS budget and timetable.

Based on these criteria, the following items, shaded in **Table 5-1**, can be addressed in Phase II:

Route 9/Route 27 interchange, Natick – conceptual alternatives
Evaluation of GMC-proposed shuttle bus services
Investigation of top "high-accident" locations (up to three)
Route 126 traffic signal coordination analysis, Framingham
Reconnaissance of Wellesley Street/Newton Street intersection, Weston



CTPS

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Potential Studies Identified in Interviews

Figure 5-1

Opportunities for New CTPS Studies in MetroWest

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TABLE 5-1
List of Potential CTPS Projects/Studies
in MetroWest

Project/Study	Source	Primary Issue(s)	Type of Work Needed/ Requested	Relation to CMS	CTPS Priority*
A. CIRCULATION STUDIES					
Route 9 / Route 27 Interchange, Natick	Natick Planner	MassHighway currently designing bridge replacement only. Town would like to see larger project, addressing issues related to turning lanes, signals, access to abutting properties on Route 27 next to interchange.	Circulation / operations study of interchange area (along both Routes 9 and 27)	High	High
Route 16 / Newton Lower Falls area	Wellesley Planner	Circulation issues in this area related to Route 128 access, proposed development (especially Stop & Shop)—area should be restudied with both Wellesley / Newton participation	Areawide circulation / traffic study	Moderate	Moderate
I-90 at I-495, Southborough	Marlborough Planner	Long backups at MassTurnpike toll booth during AM peak, extending onto I-495	Observation of queues, recommendations for improvement	Moderate	Moderate
Route 20 / Bypass Road	Weston Town Planner	Bypass Road operates as detour around existing Route 20 signal. Connections to / from Bypass Road cause congestion, queuing on Route 20. Town has rejected MassHighway proposal for signalization	Analysis of interaction between Route 20 and Bypass Road; recommendations for improvements	High	Moderate / low: best option likely to be traffic signal, which town opposes
B. TRANSIT STUDIES					
Shuttle bus service evaluation	MWGMC and Rep. Stasik	Sources desire assistance in identifying candidate routes for shuttle bus services serving the 9 / 90 and downtown Framingham areas, and evaluating such services	Review of employee survey data, identification of most likely routes / destinations based on service criteria, and evaluation of potential ridership / costs	Moderate	High
"Reverse rail / bus commute" potential in MetroWest	Several town planners and MWGMC	Towns and MWGMC believe there is potential for reverse commuting by transit modes to MetroWest industrial sites, would like help identifying scale and location of potential demand.	Evaluation of potential demand for reverse commuting	Moderate	Moderate, if scope could be agreed upon and unless already underway by others

Project/Study	Source	Primary Issue(s)	Type of Work Needed/ Requested	Relation to CMS	CTPS Priority*
LIFT 7 Evaluation	Marlborough Planner	New service connecting Framingham and Marlborough began in 1999; evaluation of factors influencing ridership growth desired.	Transit service evaluation, including definition of transit markets served, and potential for improvement	Moderate	Moderate
Natick Neighborhood Bus use study	Natick Planner	Town currently has two buses, will receive another bus from Mass Highway for senior service; requests help / advice in determining best ways to use these buses (routes, schedules, etc.)	Local transit marketing study	High	Moderate
C. ACCIDENT ANALYSES					
High-accident intersections	CTPS	Next step after production of clean "1000 high-accident locations" data	Select up to 3 Metro West high-accident locations, investigate accident types, causes, recommend improvements	Moderate: safety issues	High
Route 85 Connector safety study, Marlborough	Marlborough City Engineer	City is concerned about high accident rates on Route 85 Connector, would like to see at-grade intersections replaced with bridges / ramps in conjunction with Industrial Access Road and rail / trail development	Accident analysis, development of conceptual alternatives	Minor	Moderate: MassHighway initiating investigation of Route 85 Connector
River Road / Route 30 intersection	Weston Town Planner	Reported to be high-accident location—see Section E below	Accident review, possible analysis of improvements	High / moderate	Moderate
D. TRAFFIC SIGNAL STUDIES					
Route 126 (Framingham) traffic signal coordination	Framingham Planner	Rizzo made corridor intersection recommendations; next steps needed. Town would like to investigate a corridor signal strategy from Route 9 to south of Route 135.	Corridor-length signal timing study—6-7 signals	High	High
Route 85 (Marlborough) signal coordination	Marlborough City Engineer	Signals located along Route 85 are uncoordinated, slow traffic movements—Lincoln, Union, Hudson Street signals all within a mile of each other, should be examined in conjunction with flanking signals	Signal timing coordination study	Moderate	Moderate (may be included in CTPS signalized intersection study already underway)

Project/Study	Source	Primary Issue(s)	Type of Work Needed/ Requested	Relation to CMS	CTPS Priority*
Cedar/Walnut/River Street intersection, Wellesley	Wellesley Planner	Reported to be a hazardous location—poor turning radii, poor visibility	Accident analysis/ conceptual design for safety-related improvement	Moderate	Low
E. GENERAL INTERSECTION IMPROVEMENTS					
Route 9/ Central Street area (Fayville) in Southborough	Southborough Planner	Chronic intersection congestion on approach to 9/90. Town wishes to keep Route 9 traffic from diverting to local streets. Fayville area residents opposed to Route 9 widening, improvements.	Development of conceptual alternatives for intersection improvements	High	Moderate: low potential to find implementable improvements
Route 20 intersections at Horse Pond Road and Wayside Inn Road, Sudbury	Sudbury Planner	Congested intersections in need of improvement. Town would like some conceptual design assistance	Development of conceptual alternatives for intersection improvements	High	High/moderate
I-95 at Route 30/River Road	Mass Highway District 4	Congestion, reported safety problems	Traffic operations/ accident study	High	High/moderate
Wellesley Street/Newton Street intersection, Weston	Weston Town Planner	Outstanding weaving/merging issues remaining after recent (1998) reconstruction	Reevaluation of merging/weaving operations, and recommendations for improvement	Moderate	High/moderate
F. BICYCLE/PEDESTRIAN ENHANCEMENTS					
Route 9 from Temple Street to Country Club Lane, Framingham	Rep. Stasik	Lack of pedestrian connection between apartment complex and major shopping area	Identify R.O.W. and other issues associated with sidewalk construction along Route 9	Moderate	Moderate

***Subject to current budget constraint.**

(NOTE: Shaded rows represent CTPS recommended actions for current study)

6. CONCLUSIONS

- Continuing increases in population and employment in MetroWest communities will generate increased numbers of automobile trips and associated roadway congestion.

- This would be true *even if* major investments could be made to encourage people to shift to other modes (e.g., new transit services, HOV lanes, and the like). While commuters have the choice, the majority of new work trips and other new trips to this relatively low-density area will still be made by automobile.

- Historic traffic count data on MetroWest roadways show different patterns depending on location. Most major roadways demonstrate strong peaking patterns, reflecting the importance of commuter traffic; but additional traffic growth on these roadways is spreading to midafternoon and early evening hours. Some of this growth may represent commuter trips shifted in time; but a substantial amount is probably increased noncommuter activity, such as shopping and personal business trips, possibly combined with the trip home from work. Two-lane roads show less contrast between peak-period and off-peak volumes, and less obvious directionality.

- Most of the traffic on Route 9 and on other area roads appears to have a local (MetroWest) origin or destination—either residence or work site—and is not "through" traffic.

- The geography of the employment sites in MetroWest, as well as the increasing dispersion of employee origins, mean that few locations exist where the minimum ridership could be identified to justify fixed-route bus service.

- Ride-sharing initiatives, including carpooling, vanpooling, and shuttle connections to the nearby rail stations and long-distance bus stops, offer better trip-reduction possibilities than do new transit services for most MetroWest employer locations, especially the newer locations. Such initiatives can be very successful at locations where employer commitment is high, as evidenced by active participation in the TMA and willingness to subsidize and/or otherwise support employee ride-sharing activities. Traditional fixed transit will be more successful at serving more traditional transit markets (i.e., transit-dependent persons traveling between densely-developed origins and destinations).

- It remains true, however, that the most effective methods for controlling congestion in this area would involve planning and land use control measures to limit growth and increase both residential and employment densities to the level where ride-sharing and limited transit begin to become effective. Such measures typically include zoning modifications, use of overlay districts, permitting controls and site plan reviews, parking bylaws which specify maximum, rather than minimum allowable spaces for new developments, and limits on building permit issuance.

- Quite a few of the congested locations identified in the 1997 CMS report are currently being addressed through projects within MassHighway or the MBTA, through local initiatives, or through studies currently ongoing at CTPS. Planned projects can *relieve* congested operations at many locations; however, they are unlikely to *eliminate* congestion caused by continued low-density growth.

  Of the locations which remain outstanding, as well as others identified in discussions with town planners, several will be examined in Phase II of the present study. This will not be a one-time effort, but will be approached as a continuing process of consultation with town planners and others about needed and potentially useful study efforts.

APPENDIX A

Previous Transportation Studies in MetroWest
(by CTPS and Others)

APPENDIX A
Previous Transportation Studies in MetroWest (by CTPS and others)

A.1. Route 9 Corridor Study (1985-1989)

The basis for planning in the Route 9 corridor was a multi-year series of studies conducted in the mid-1980s by the Central Transportation Planning Staff (CTPS) and Central Massachusetts Regional Planning Commission (CMRPC). CTPS covered the section of Route 9 between I-95 (Route 128) and I-495—essentially the entire length of Route 9 through MetroWest—while CMRPC focused on the section between I-495 and Lincoln Square in downtown Worcester.

The Route 9 MetroWest study began by demonstrating the growth in population, employment and traffic volumes in the Route 9 corridor to that time. The study used a traffic model to project traffic to year 2010 under a variety of different scenarios, including several different 'build-out' scenarios based on work done by the Metropolitan Area Planning Council (MAPC).[1]

Apart from general issues of continued development and traffic growth, problems identified along Route 9 by these studies included the following:

- poor interchange connections between I-90 and Route 9 in the Golden Triangle area, which require traffic to use Route 30, Speen Street, and/or the substandard Route 9/126 interchange to make these connections.
- generally poor north-south roadway connections in the area south of the Golden Triangle, as well as in Southborough, Natick and Wellesley.
- high volumes of turning traffic at intersections in Framingham (Prospect Street, Edgell Road) creating inefficient and congested signal operations.
- congestion at Route 9 intersections in Southborough caused by traffic approaching the California Avenue industrial park in Framingham.
- limited right-of-way along Route 9 with intensive abutting development and frequent driveways generating friction between through and entering/exiting vehicles.

Among the assumptions of the Route 9 studies for the MetroWest segments were:

- MassHighway's policy will be to limit the granting of new access to Route 9 in order to avoid further erosion of capacity and safety.
- MassHighway's policy is to provide median barrier separation along Route 9, closing median openings where possible and providing alternate access where necessitated by median closure.

[1] Metropolitan Area Planning Council, "Route 9 Corridor Planning Study: Land Use Scenario", July 15, 1987.

The Golden Triangle studies started from a "no-build" base condition which assumed several elements which have not been implemented as yet, (or, in some cases, are unlikely ever to be implemented):

- a new diamond interchange on Route 9 west of Dean Road, Natick.
- the completion of an east-west connector to Caldor Road.
- the construction of a regional Transportation Center on Route 30.
- improvements to the Route 30 / Speen Street intersection[2].

The additional roadway improvement alternatives examined for the Golden Triangle area included improvements at a number of strategic points around the area, including:

- new direct connections to I-90 EB from Speen Street.
- new direct connections to Route 30 EB from Route 9 EB, in conjunction with a rebuilt and expanded Route 9 / 126 interchange.
- additional service roads on both sides of Route 9 adjacent to the assumed diamond interchange.

A supplemental report on the Golden Triangle examined additional alternatives designed to reduce the number of internal circulation trips within the area, notably:

- a Regional Transportation Center (not constructed as yet).
- a mini-bus program to supplement the existing shuttle services (effectively implemented through expansion of The Lift).
- intensive carpool / vanpool marketing, under the auspices of a Transportation Management Association (TMA).

The Route 9 study element which covered the remaining sections of Route 9 in Metrowest (Wellesley, Natick, West Framingham and Southborough) examined the types of geometric improvements which would be required to permit operation at LOS C at existing intersections and interchanges. The recommendations tended to consist of the following actions:

- widening Route 9 intersection approaches to 3 through lanes where appropriate.
- adding turning lanes, or prohibiting specific turning movements, at locations where these consume a significant amount of existing signal capacity.
- constructing jug-handle intersections to handle left and u-turns at high-volume locations.
- reconstructing interchanges (notably the Route 9 / Route 85 interchange) to provide adequate acceleration / deceleration lanes.

[2] The last of these, Route 30 / Speen Street intersection improvements, did advance to project development, and is scheduled for construction beginning in Spring 1999.

No recommendations were provided for 2 locations: Route 9 at Edgell Road, Framingham (more complex traffic model required); and Route 9 at the I-90 interchange, Framingham (recently reconstructed with largely private funding).

As suggested, a number of specific recommendations from the CTPS Route 9 studies were implemented (Route 30 corridor improvements, and TMA activity in Framingham). In addition, several are nearing the end of design or beginning of construction (e.g., Route 30/Speen Street intersection improvements, Route 9/126 interchange improvements, Oak Street intersection improvements in Natick). Still others have been rendered moot by added development and changing circumstances and priorities. The Draft reports from the Route 9 study were never advanced to the point of formal adoption.

A.2. Route 20 Corridor Study (1987-1991)

A similar study effort was undertaken by CTPS in the Route 20 corridor through the northern-tier towns of MetroWest (Weston, Wayland, Sudbury and Marlborough). Like the Route 9 study, this study included a major traffic modeling component, and forecast traffic demands to a future year (2010). During the course of the study, there was considerable interaction with the MetroWest Transportation Task Force of the Growth Management Committee, as well as the individual towns involved, in developing the study alternatives and evaluating its conclusions.

Initially, the study examined the effects of developing a 4-lane cross-section on the entire length of Route 20, or on selected segments where acute congestion was observed. (Sections of Route 20 in Marlborough were at that time already committed to be widened to 4 lanes). Over time, the 4-lane cross-section alternatives were essentially rejected for most of Route 20, with attention focused instead on intersection and/or traffic signal improvements at key locations, analysis of the potential applicability of transit service within the corridor, and consideration of adding sidewalks and a park & ride lot. The intersection of Route 20 and Old Connecticut Path was identified as a prime candidate for future signalization.

The principal recommendations of the study were:

- in Marlborough, widening of Route 20 from Stevens Street to just west of the Marlborough-Sudbury town line
- in Sudbury, extending Nobscot Road to eliminate the "dog-leg" intersection with Union Street on Route 20
- in Wayland, reconstruction of the Route 20/27/126 intersection, channelization at the Pelham Island Road approach to Route 20, and creation of a commuter park & ride lot
- in Weston, striping of Route 20 as a 3-lane roadway, with coordinated traffic signal control at the Route 20 intersections with Highland Street, School Street and Wellesley Street.

Of these recommendations, the widening of one section of Route 20 East in Marlborough is included in the current TIP, and the Route 20/27/126 intersection in Wayland has

been under design for several years. Improvements were also made to the traffic signal at Route 20 and School Street in Weston.

A.3. Other area studies and proposals

The two major corridor studies described above represent the primary involvement by CTPS in MetroWest area studies prior to the current Congestion Management efforts. In addition to these, the following studies represent a sample of CTPS work undertaken in the past or currently underway in MetroWest:

- CTPS worked with a group of major local businesses and their consultant (VHB) on the West Marlborough Area Study in 1989-90. That study developed several alternative future development scenarios, and evaluated different transportation improvement strategies which would be needed to allow adequate levels of service under each scenario, including a proposed new interchange on I-495 south of Route 20.

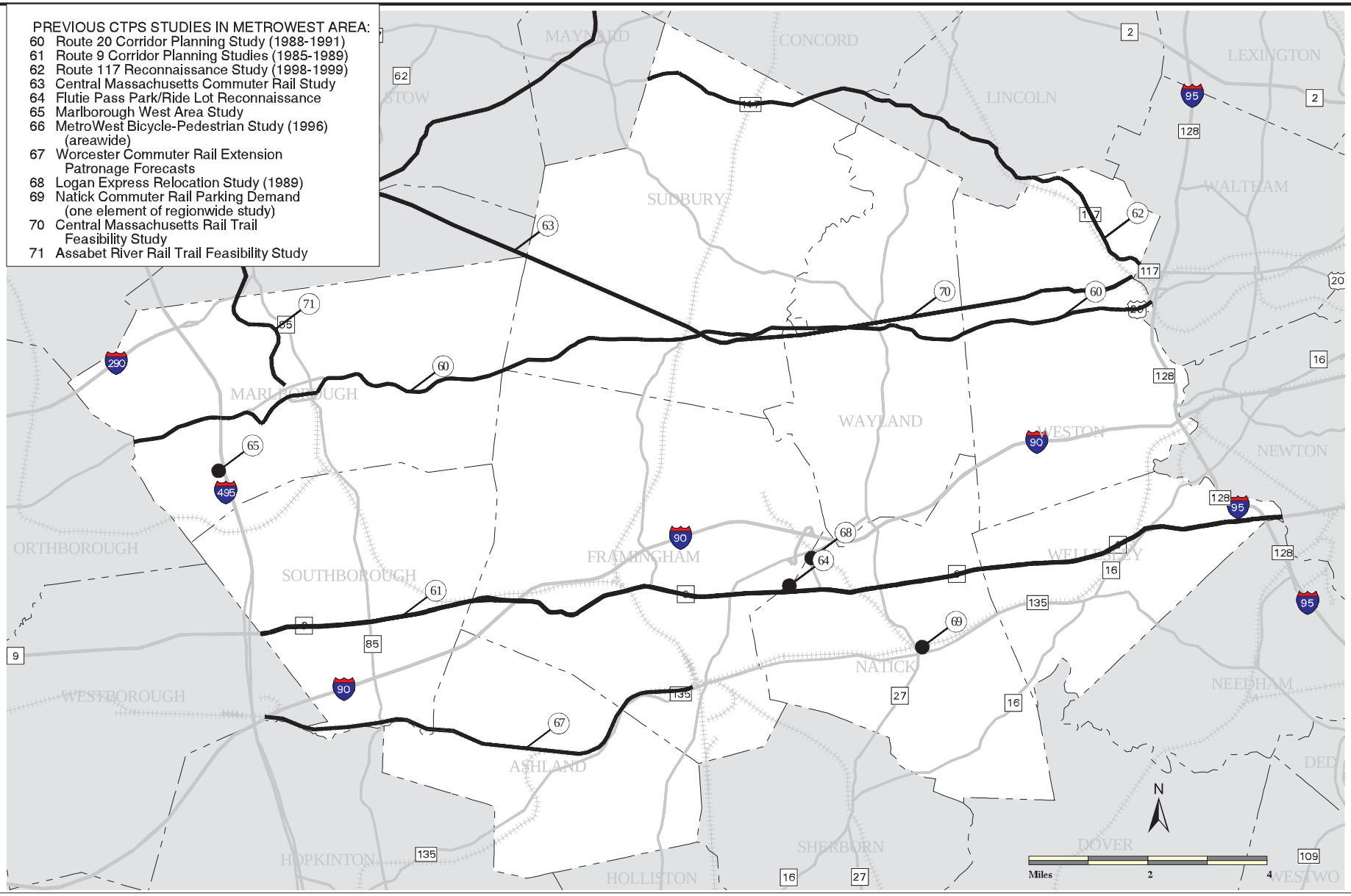
- Several unused or little-used railroad rights of way were studied to determine their suitability for reuse for commuter rail, bicycle paths or nature trails, or other uses. These included the Central Massachusetts right-of-way and the Assabet River Rail Trail. Currently, two studies are underway, focusing on reuse of the Fitchburg Secondary rail line for commuter service to I-290 in Northborough; and feasibility of developing a rail trail on the Saxonville Branch through Natick and Framingham. CTPS also provided patronage forecasts for the extension of commuter rail service to Worcester.

- Park & ride lot studies were conducted at selected commuter rail stations where parking lots are currently full, with an aim to identifying additional park & ride locations. Also, several studies have been undertaken at the underutilized park & ride lot at Shoppers' World, Framingham, to determine steps needed to increase its attractiveness to potential park-riders.

Figure A-1 highlights elements of CTPS involvement in MetroWest transportation studies since the mid-1980s.

In addition, the MetroWest area has been subject to many site-specific traffic studies, as well as town-sponsored corridor studies, over the past several years, as the economy has allowed development to proceed aggressively.

The most complex and comprehensive of these have been related to the *Golden Triangle* area in Framingham / Natick: the redevelopment of the Shoppers' World site; the expansion of the Natick Mall; and related individual developments (e.g., the General Cinema complex at Flutie Pass). As a result of these developments, an areawide package of traffic mitigation-related improvements was identified and constructed largely with private financing. The improvements included reconstruction of driveway, intersection and frontage-road connections with Route 9 in the vicinity of both malls;



CTPS
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Figure A-1
Previous CTPS Studies in Metrowest (since 1980s)

and the design and construction of "closed-loop" traffic signal systems connecting the major intersections in the vicinity of both malls.

A second area where private interests have been heavily involved in financing roadway improvements is at the *9/90 interchange*, where the MassPike meets Route 9 in west Framingham. Two large-scale industrial parks are located directly adjacent to the interchange: the Framingham Technology Park, north of Route 9, with access from California Avenue in Framingham and Boston Road in Southborough; and the "9/90 Crossing" complex located on the south side of Route 9. Access to the latter is via ramps and a new bridge constructed a few years ago with private funding. Additional work is continuing in the vicinity of 9/90, including improvements to intersections on Route 30 and Route 9, and the creation of a median break opposite the California Avenue approach to Route 9, with an eastbound left-turning lane and new traffic signals.

The studies identified below represent only a partial list of other recent traffic/transportation studies conducted within MetroWest, principally in conjunction with private developments. Other pending projects (e.g., redevelopment of the Continental Bakery site in Natick, development parcels in Southborough, Sun Life expansion in Wellesley) have not yet filed for permits/approvals.

Framingham:
1. Route 126 Corridor Study (Town of Framingham by Rizzo Associates, 1998)
--focused on intersection improvements and presented a feasibility analysis for grade-separating Route 126 at Route 135 in downtown Framingham.
2. Proposed TJX Companies Expansion (for Campanelli Associates by VHB, Inc., September 1997, and subsequent responses to comments)
--300 ksf added to existing corporate headquarters

Natick:
1. Apple Hill Phase IIb (Rizzo Associates, 1997 and following)
--access alternatives involving Route 9 median break for office park expansion

Marlborough:
1. Rosewood/Forest Street Office Building (MetroWest Engineering, 1997)
--38 ksf added to existing office building
2. Waterford Park FEIR (Hayes Engineering, 1998)
--400 ksf office adjacent to I-290 at Solomon Pond interchange
3. Cedar Hill Industrial Center (for Tambone by Vollmer Associates, 1998)
--119 ksf warehouse/distribution center
4. Crane Meadow Road Office Building (VHB, 1997)
--200 ksf office building
5. Windsor Corporate Center (VHB, 1996)
--addition of 71 ksf office to existing facility; mitigation includes upgrade of Boundary Street, and design of Route 20 between Boundary Street and I-495
6. 3COM and associated roadway improvements
--up to 1.2 million sf overall; Functional Design Report prepared for intersection improvements at 5 Route 20 locations

7. Lake Williams Corporate Center (CDW Consultants/RDVanasse, 1997)
--455 ksf office/R&D/light manufacturing, plus 140 room hotel
8. Jefferson at Wheeler Hill (Sumner Schein, 1998)
--13 buildings, 408 apartment units adjacent to I-495/I-290 interchange

Southborough:
1. Route 9 Crossing Study (for Town of Southborough by SEA Consultants, 1997)
--examined alternatives for new bridge crossing of Route 9 near Parkerville Road

Ashland:
1. Shaw's Supermarket Expansion (HTSD, 1998)
--added 9,400 sf to existing existing 42,125 supermarket

Sudbury:
(None identified)

Wayland:
1. Route 30 Corridor Study (for Town of Wayland by D. Friend, 1997)
--detailed study of traffic-calming potential for Route 30 in Wayland

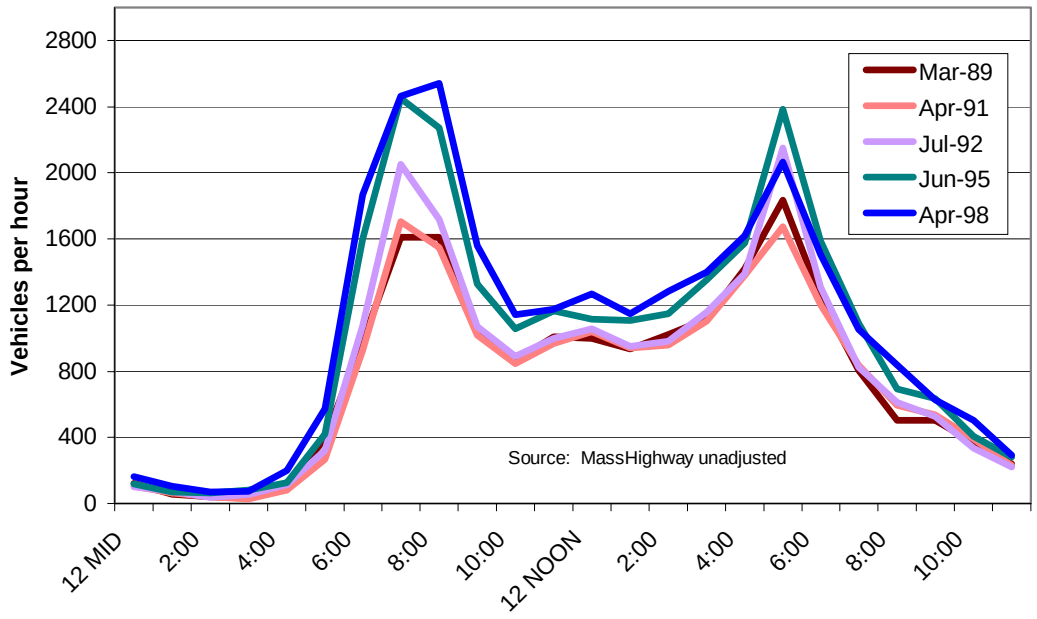
Wellesley:
1. Harvard Pilgrim Health Care (RDVanasse, 1997)
2. Warren School Renovations (Howard/Stein-Hudson, 1998--preliminary draft only) --
--circulation study related to school reuse project
3. Super Stop & Shop, Washington Street (VHB, 1997)
--proposed supermarket on Route 16
4. Dana Hall School—full analysis and addendum (Rizzo, 1997)

Weston:
1. ADL/Weston Corporate Center (Beals & Thomas/VHB, 1995+)
--350 ksf office for single tenant, adjacent to I-95

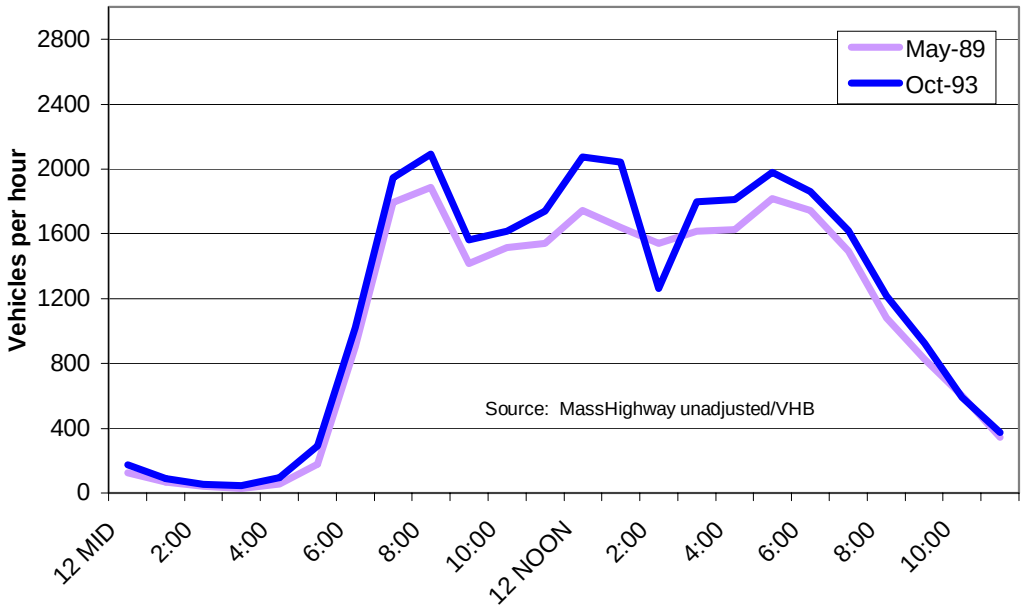
In addition to their value as the basis for negotiating mitigation commitments, these studies have value as a measure of the intensity of activity at particular locations, and as a record of traffic growth. Many of the traffic counts referrred to in this memorandum were obtained from traffic studies performed for specific development proposals.

APPENDIX B

Historic Traffic Volumes on
Selected MetroWest Roadways

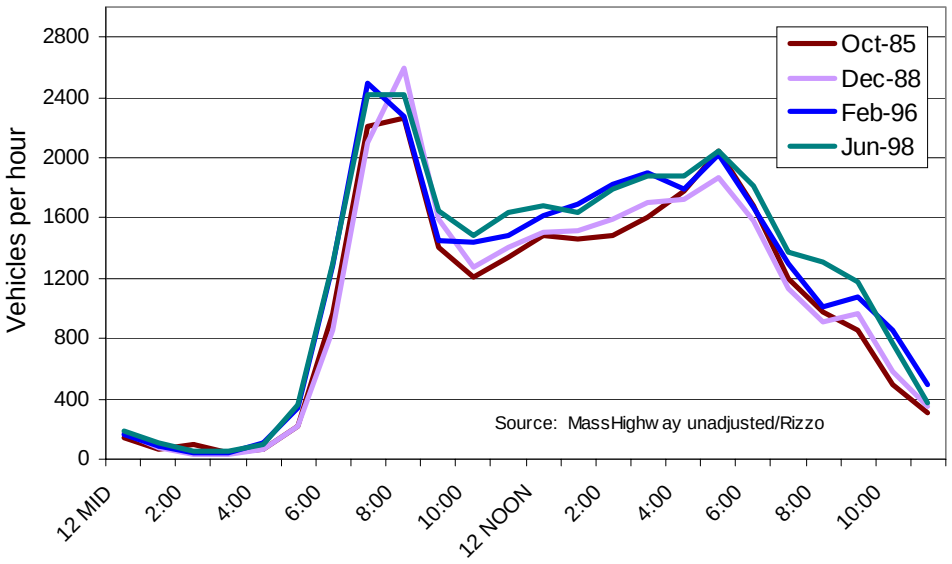


A. Route 9 Southborough: West of Woodland / East of White-Bagley Road (EB)

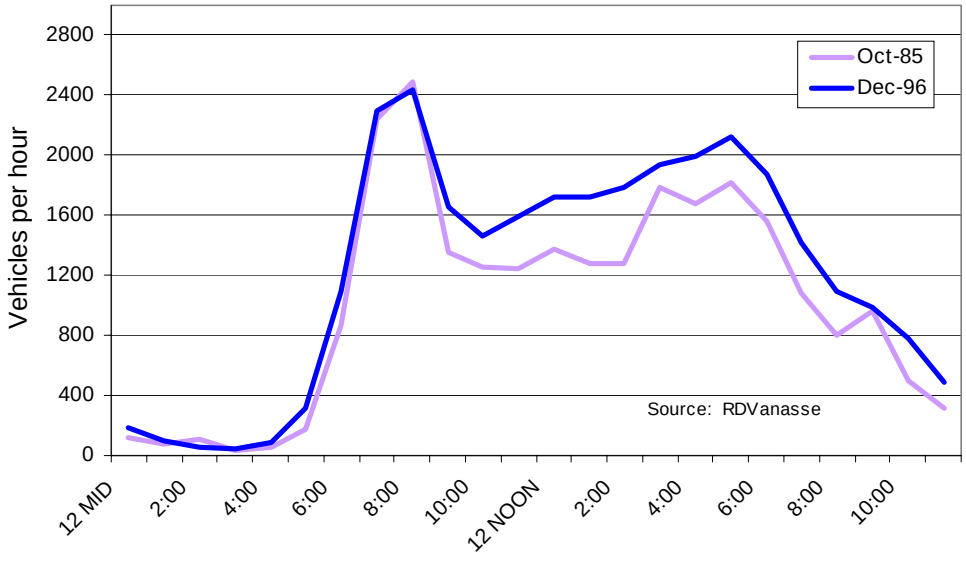


B. Route 9 at Framingham / Natick Town Line (EB)

Figure B-1
Historic Traffic on Route 9 EB--Southborough and Framingham/Natick

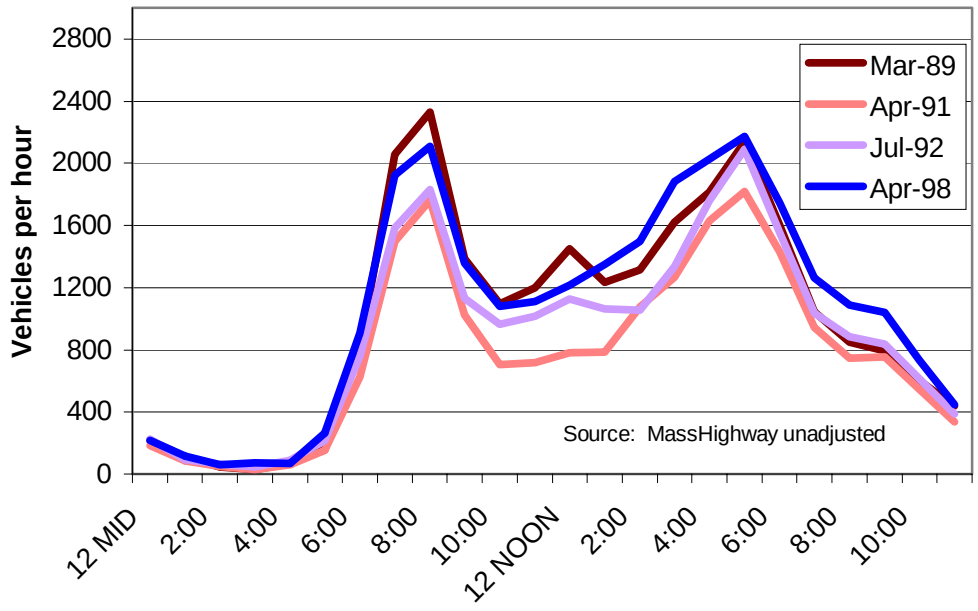


C. Route 9 Wellesley: Overbrook Road / Weston Road vicinity (EB)

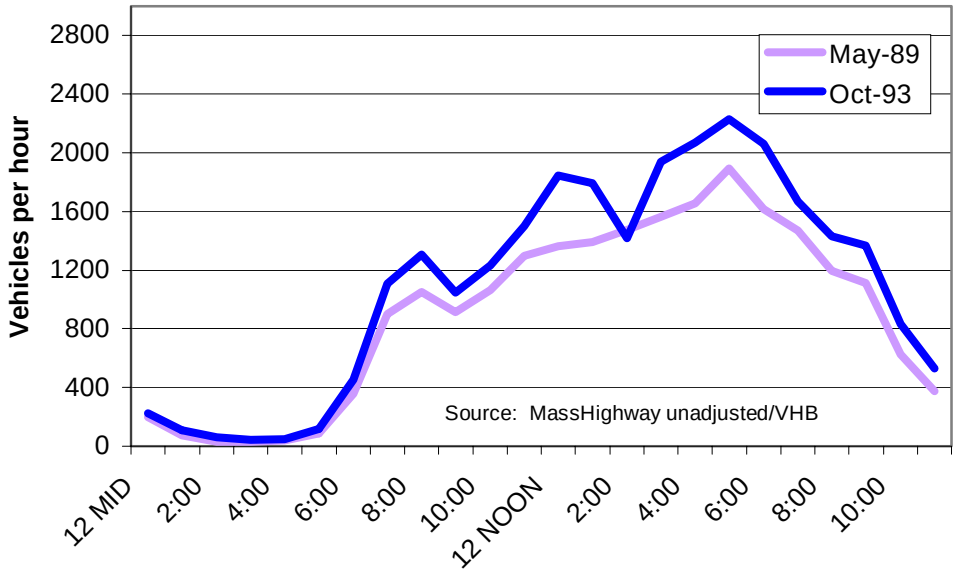


D. Route 9 Wellesley: East of Cedar Street (EB)

Figure B-2
Historic Traffic on Route 9 EB--Wellesley (2 locations)

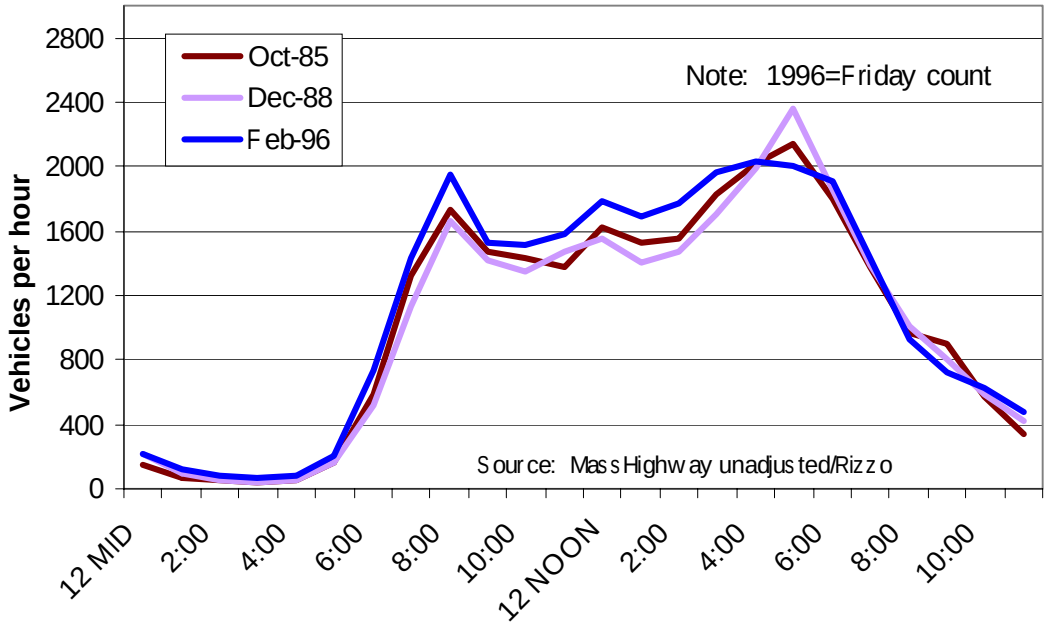


A. Route 9 Southborough: West of Woodland / East of White-Bagley Road (WB)

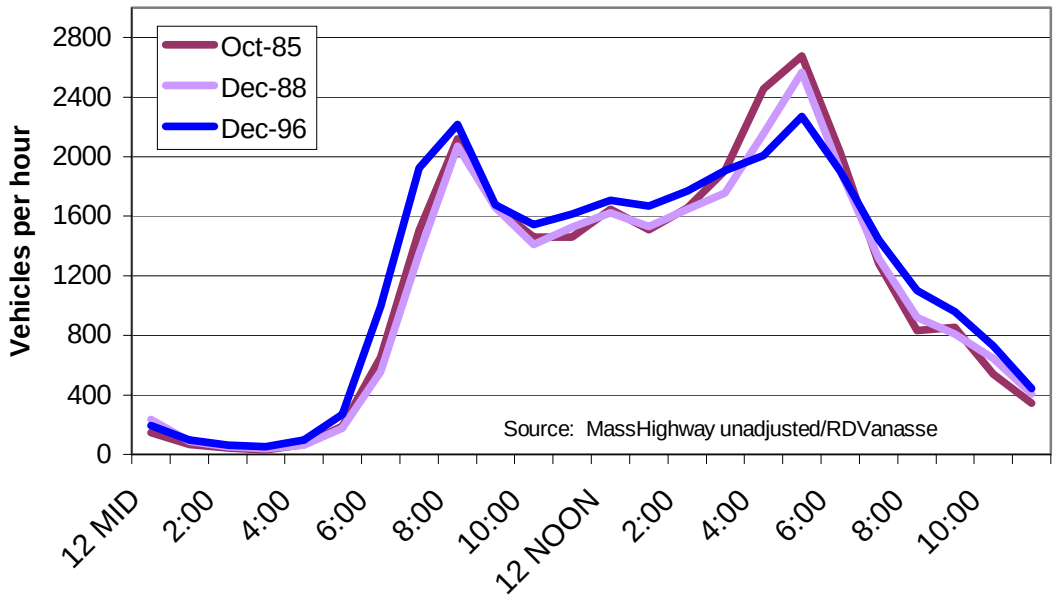


B. Route 9 at Framingham / Natick Town Line (WB)

Figure B-3
Historic Traffic on Route 9 WB--Southborough and Framingham/Natick

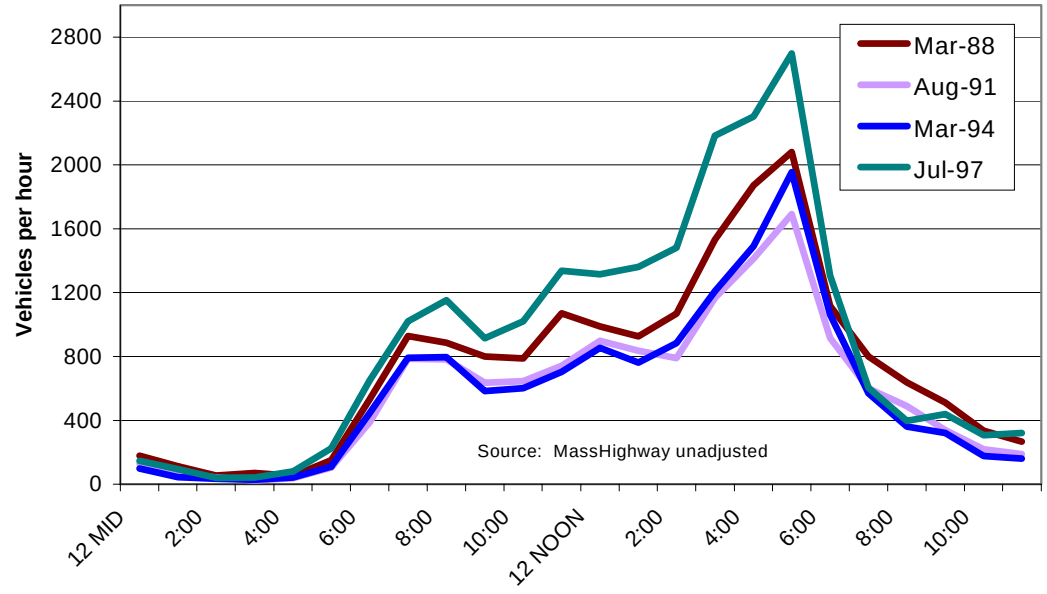


C. Route 9 Wellesley: Overbrook Road / Weston Road vicinity (WB)

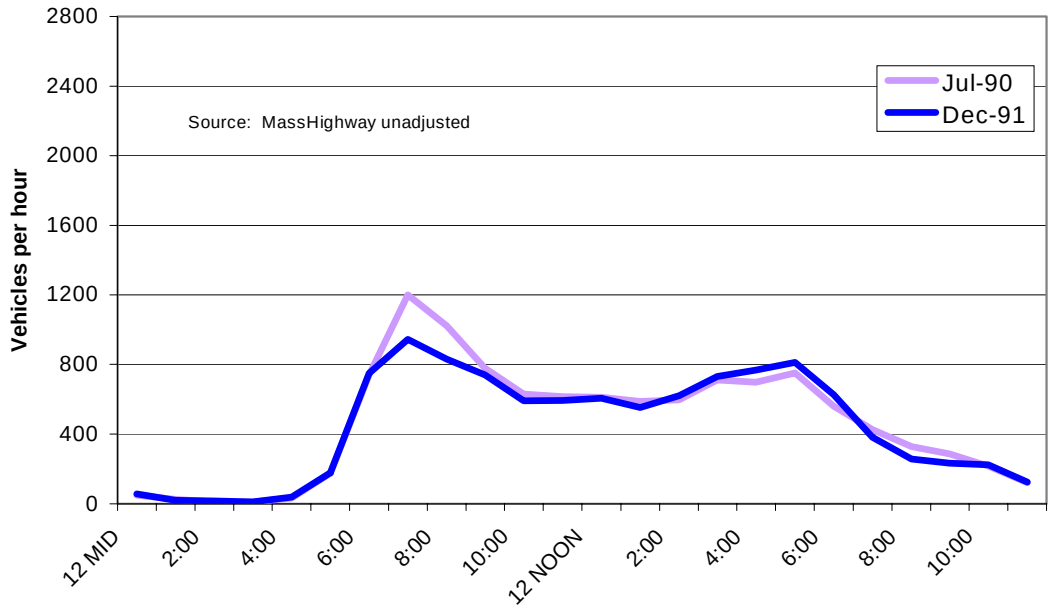


D. Route 9 Wellesley: East of Cedar Street (WB)

Figure B-4
Historic Traffic on Route 9 WB--Wellesley (2 locations)

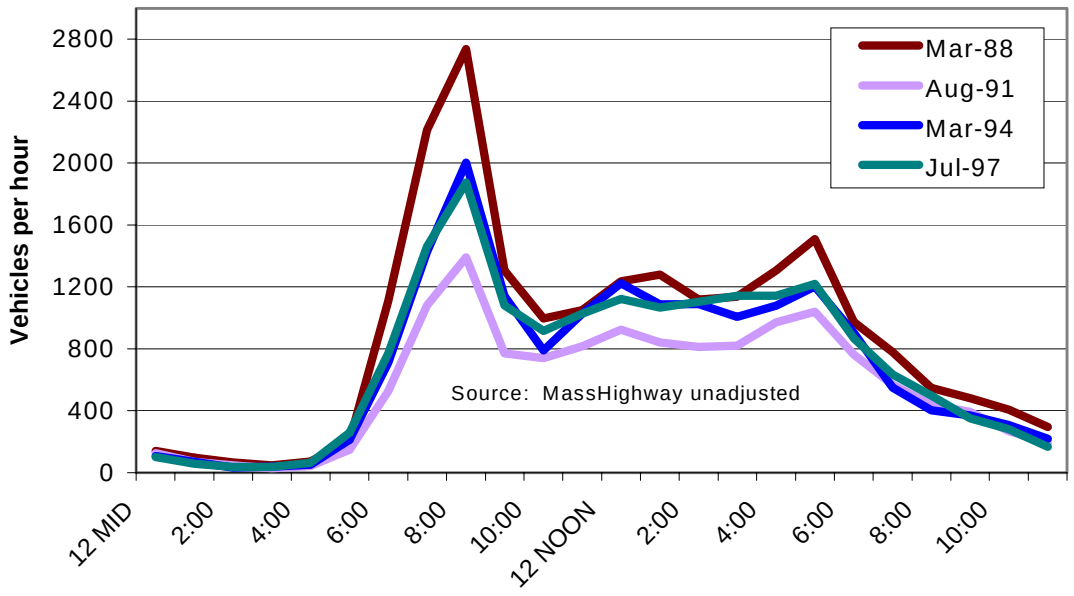


A. Route 20 Marlborough West of I-495 (EB)

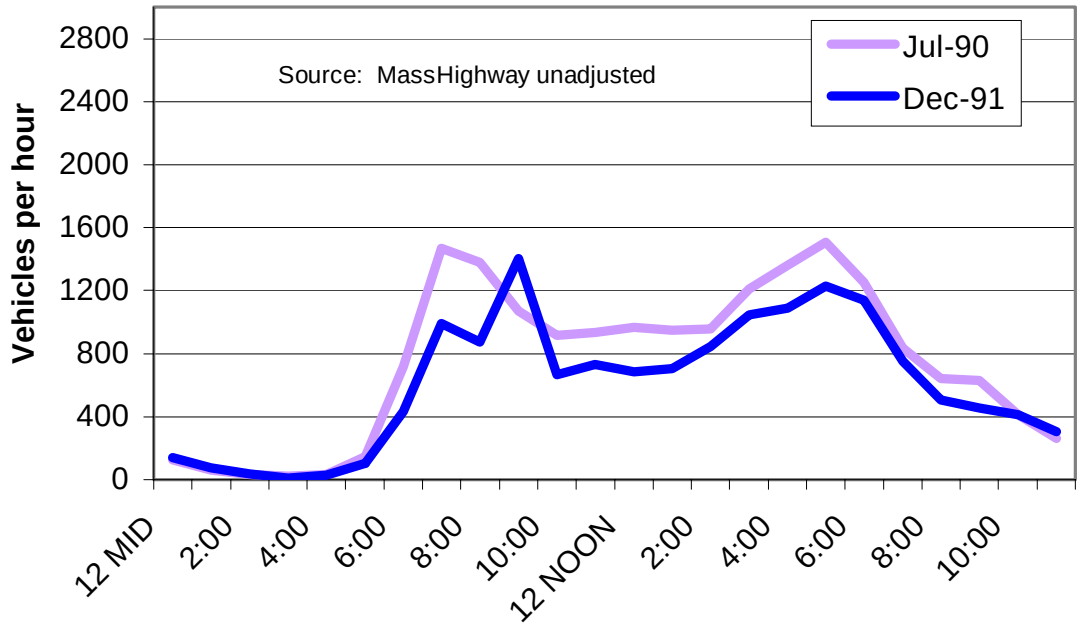


B. Route 20 Wayland West of Old Connecticut Path (EB)

Figure B-5
Historic Traffic on Route 20 EB--Marlborough and Wayland

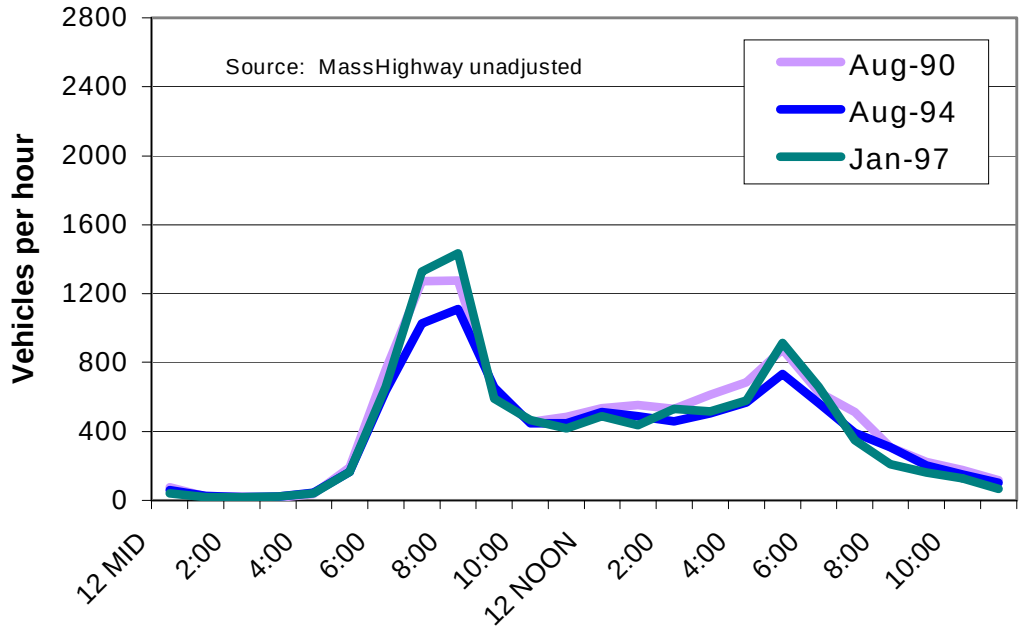


A. Route 20 Marlborough West of I-495 (WB)

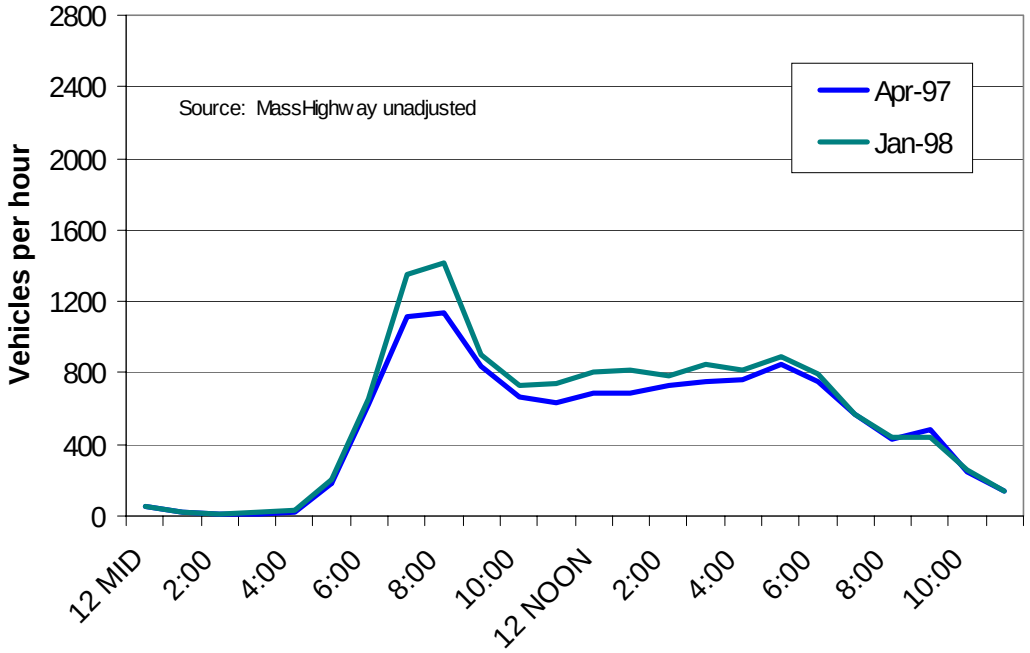


B. Route 20 Wayland West of Old Connecticut Path (WB)

Figure B-6
Historic Traffic on Route 20 WB--Marlborough and Wayland

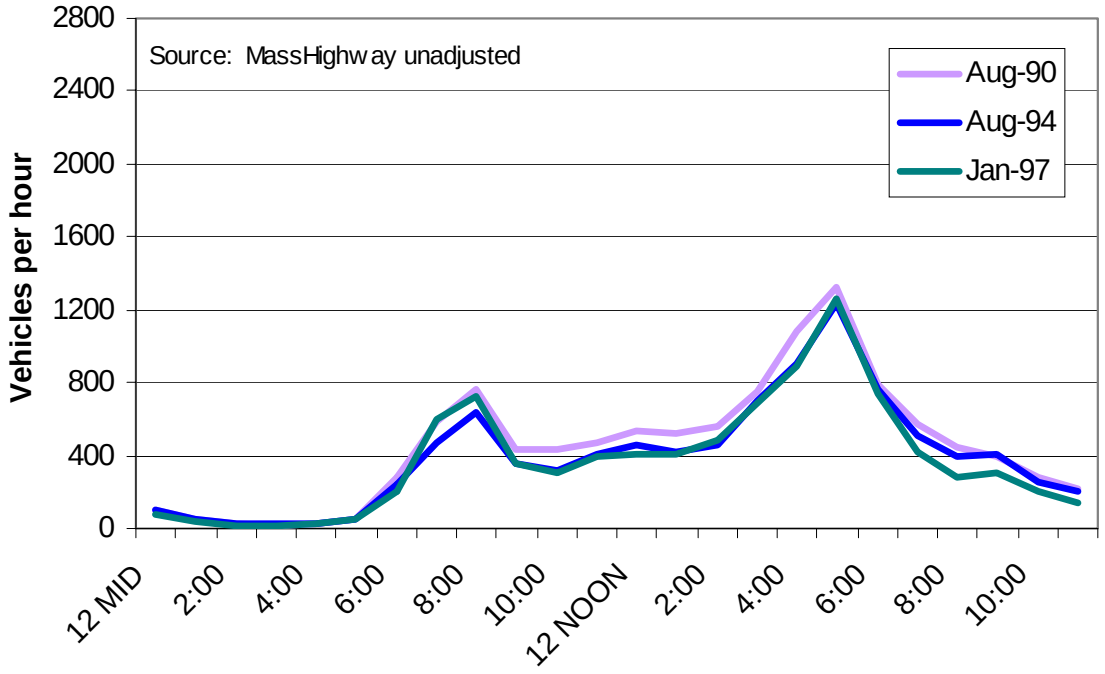


A. Route 30 Southborough West of Valley Rd (EB)

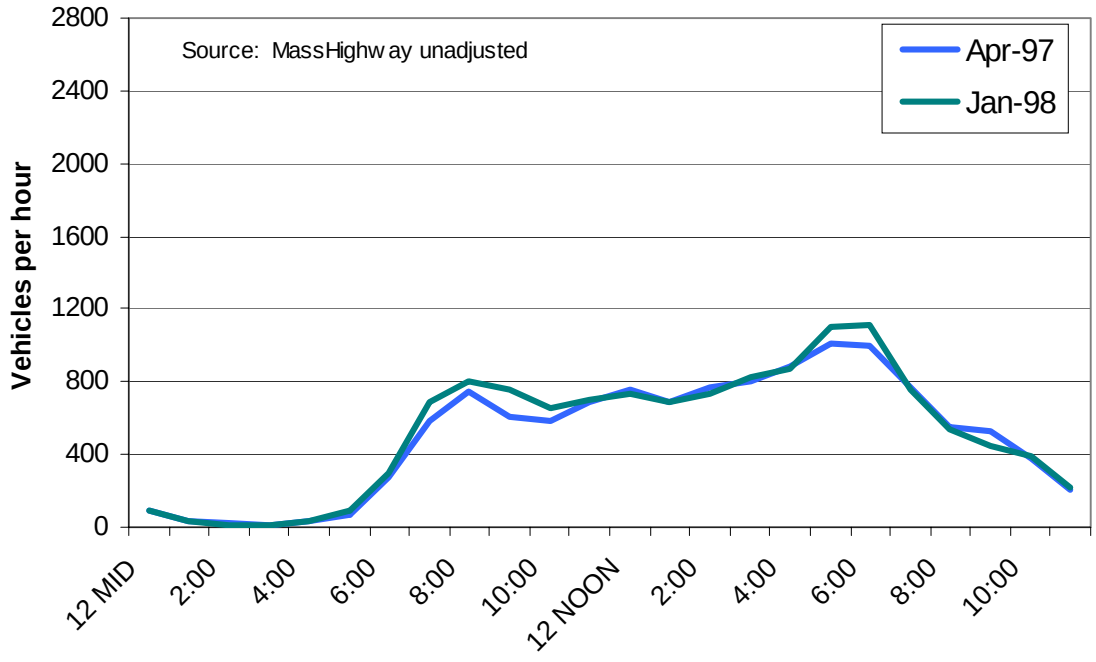


B. Route 16 Wellesley East of Woodlawn (EB)

Figure B-7
Historic Traffic on Selected East-West Roadways: Eastbound



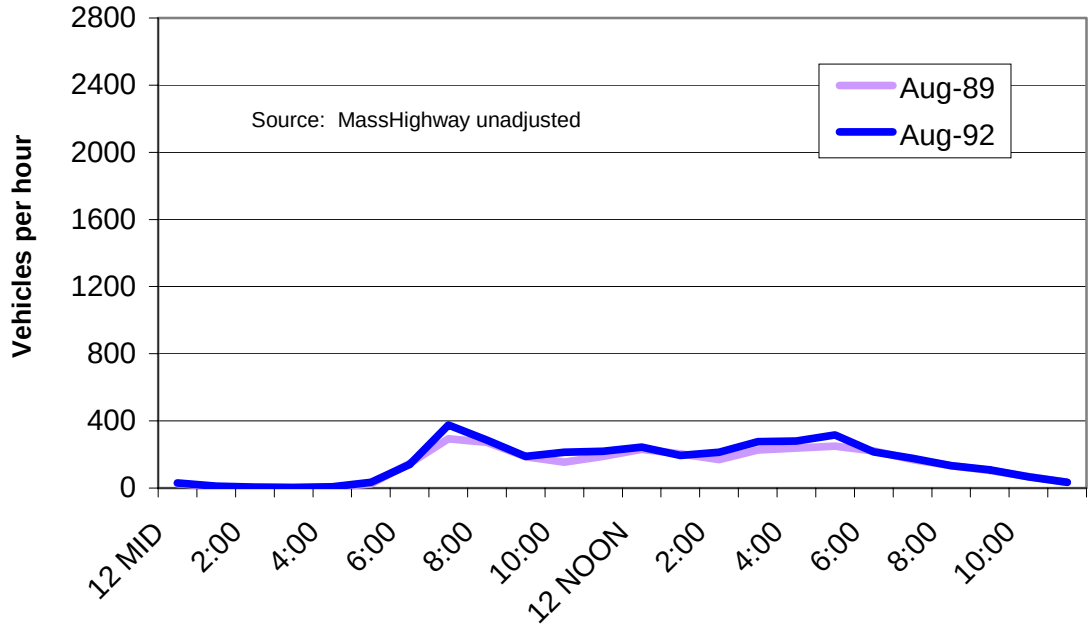
A. Route 30 Southborough West of Valley Rd (WB)



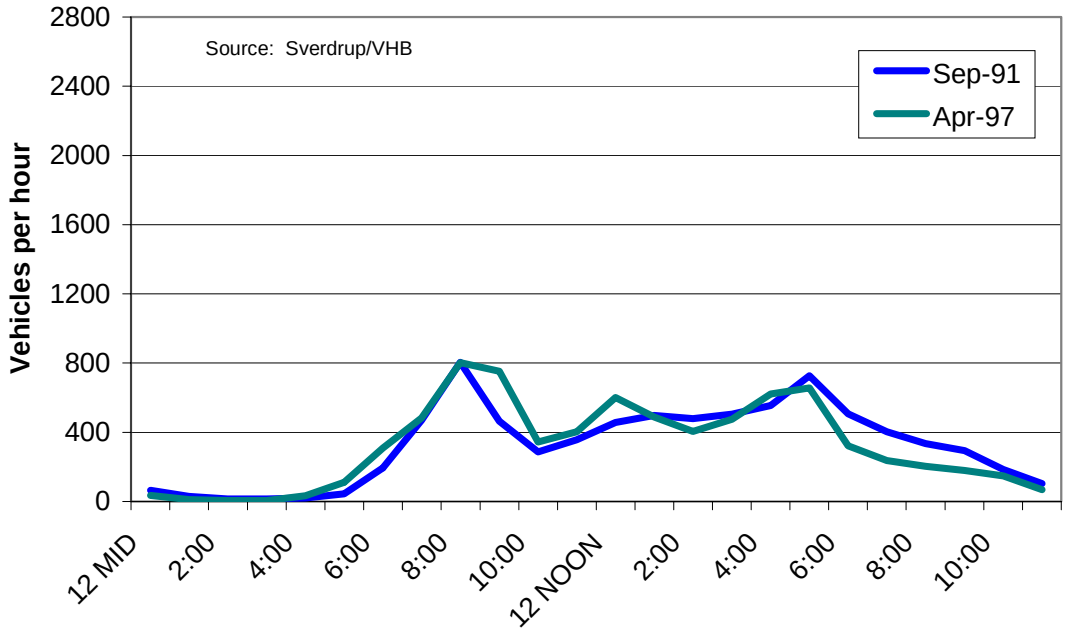
B. Route 16 Wellesley East of Woodlawn (WB)

CTPS
MetroWest Subregional Area Study

Figure B-8
Historic Traffic on Selected East-West Roadways: Westbound

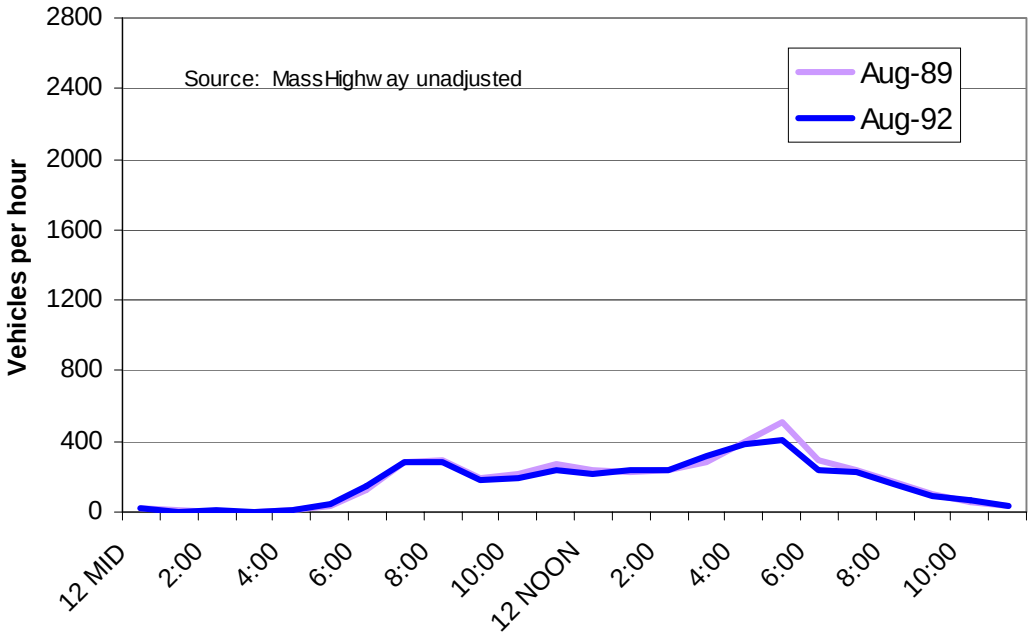


A. Route 85 Southborough North and South of Cross St (NB)

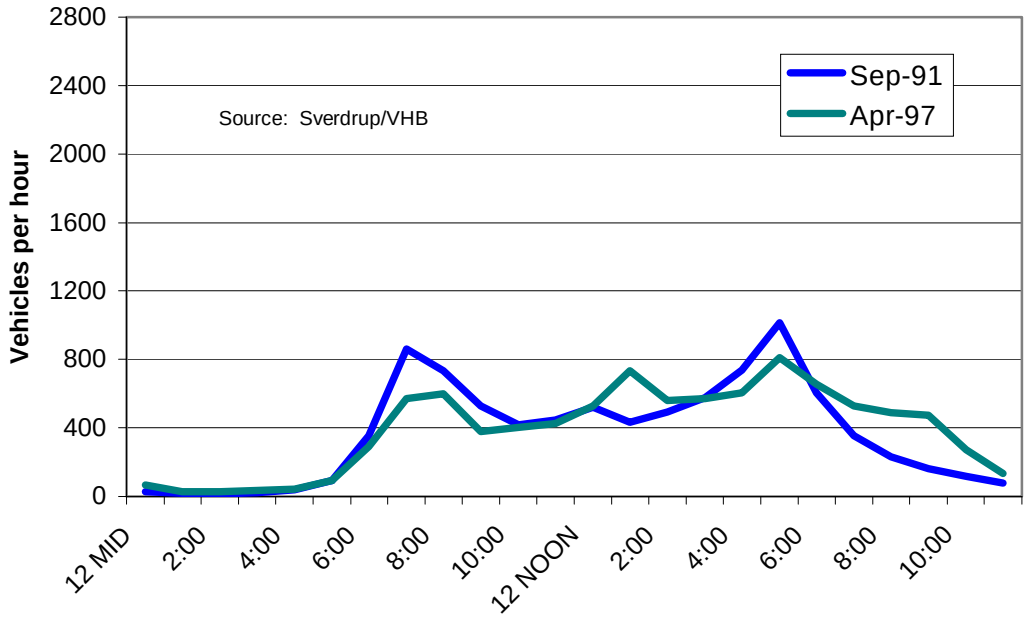


B. Speen Street North of Route 30 (NB)

Figure B-9
Historic Traffic on Selected North-South Roadways: Northbound



A. Route 85 Southborough North and South of Cross St (SB)



B. Speen Street North of Route 30 (SB)

Figure B-10
Historic Traffic on Selected North-South Roadways: Southbound

APPENDIX C

Current Projects and Studies
in MetroWest Communities

TABLE C-1
Current Projects and Studies--ASHLAND

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
601875	Cordaville Rd.	Repaving	Partly completed in 1998; remainder awaiting construction	FIG 4-2, # 1
26703	Fountain St. Bridge	Bridge replacement	Awaiting construction	FIG 4-2, # 2
160060	High St. Bridge	Bridge replacement	Under construction	FIG 4-2, # 3
602065	Main St.	Resurfacing	Not currently programmed	FIG 4-2, #42
602064	Pleasant St	Resurfacing	Not currently programmed	FIG 4-2, #43

B. Locally Advanced and Developer-Sponsored Projects

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 126 Corridor Study	Corridor Study (IEP / TAMS, 1992) recommended design criteria for Route 126 reconstruction	Recommendations not yet implemented; Town has requested Design Study from Mass Highway	FIG 4-3, # 1
	Route 126 / Eliot Street Traffic Operations Report	Safety Study (Vollmer / HTSD, 1993) for MassHighway under Statewide Traffic Eng'g Services Contract; made safety recommendations	Recommendations constructed	FIG 4-3, # 2
	Main St. Grade Crossing	Town would like to see grade crossing removed to eliminate traffic delays	(not included in MBTA's Worcester Extension project)	FIG 4-3, # 3
	Areawide Development Impact Study	Study (McDonough / Scully, 1992) looked at build-out of 15 residential subdivisions	Some developments advanced; others expected within 3-5 years	FIG 4-3, # 4
	West Union / Frankland / Olive Street Intersection, Ashland	Bad vertical / horizontal geometry. Currently unsignalized. Town regards as safety issue.	Town seeking assistance in development of concepts for intersection improvement.	FIG 4-3, # 22

C. Previous CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	(None identified, apart from patronage projections for Worcester Extension)			

Table C-1 (cont'd) – Current Projects and Studies—Ashland

D. Active/Pending CTPS Studies

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
(None identified)			

E. Additional Study Needs Identified

LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
(None identified)			

TABLE C-2
Current Projects and Studies—FRAMINGHAM

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
600504	Rte. 9-Caldor Rd.	Intersection improvement	On hold pending negotiations with new property owner	FIG 4-2, # 4
--	Downtown Streetscape, Phase 1	Improved signing in Downtown Framingham, paid for through ISTEA Enhancement funds	Signs fabricated, installed in 1998	FIG 4-2, # 6
601662	Rte. 9-California Ave.	New median break on Route 9 with signal modifications, geometric improvements	Under construction	FIG 4-2, # 5
110952	Rte. 30-Speen St.	Geometric and signal improvements	Advertised 1998, construction expected Spring 1999	FIG 4-2, # 7
86450	Rte. 126-Rte. 30	Intersection improvements	Re-programmed FY 2000; Town currently renewing takings agreements, getting mortgage sign-offs	FIG 4-2, # 21
600577	Rte. 135 (Waverly St.)	Reconstruction / resurfacing	Final design completed	FIG 4-2, # 22
601311	Warren Rd. / Dennison Ave.	Roadway reconstruction	Currently at 100% design	FIG 4-2, # 23
--	Downtown Streetscape, Phase 2	Pedestrian improvements, focusing on area between Memorial Building and Common.	Local Enhancement Project	FIG 4-2, # 40
602839	Central St. Bridge over Sudbury River	Bridge replacement	Programmed in FY 2002	FIG 4-2, # 24
602046	Franklin St. reconstruction	Roadway reconstruction	Programmed in FY 2002	FIG 4-2, # 25
602038	Traffic Signal upgrade at 6 locations	Recommendations made by Town-sponsored Route 126 corridor study	Local project, not currently programmed	FIG 4-2, # 44
602624	Rte. 126 Bridge over Rte. 9 (replacement)	Bridge replacement	Currently in design; programmed in FY 2002	FIG 4-2, # 26
602522	Rte. 9 Bridge	Bridge replacement over Sudbury River	Not currently programmed	FIG 4-2, # 51
602464	Winter St., Two Bridges (over Sudbury River)	Replacement of bridges over Sudbury River	Not currently programmed	FIG 4-2, # 52
--	Route 126 between Hartford and Lincoln St.	Intersection improvements, signal upgrades	Not currently programmed	FIG 4-2, # 45
--	Route 126 at Route 135	Environmental / Major Investment studies of proposed grade separation	Not currently programmed	FIG 4-2, # 46

Table C-2 (cont'd) – Current Projects and Studies—Framingham

B. Locally Advanced and Developer-Sponsored Projects

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
Route 126 Corridor Study	Feasibility study of Route 126/Route 135 grade separation, plus recommendations for intersection improvements, Route 126 corridor (Rizzo, 1996)	Town would like more funding to complete, extend study; improvements to 6 intersections included in TIP (ID# 602038)	FIG 4-3, # 5
Route 135/ Beaver St garage	Possible public/private development of garage serving MBTA commuters and Dennison/Rosewood employees	In negotiation with Town	FIG 4-3, #6
3 Intersections near Dennison Crossing	Town upgrading 3 locations using PWED money	Advertised 1997; much of work now completed	FIG 4-3, #7
Added parking for MBTA commuters	Town examining options for adding garage parking close to commuter rail station, in conjunction with planned MBTA station relocation	Town in negotiation with MBTA, land-owners	FIG 4-3, #8
Route 9 at Temple Street	Town-sponsored reconnaissance of potential for improvements at this intersection	Memorandum prepared by consultant (HTSD); no further action at present	FIG 4-3, #22

C. Previous CTPS Studies

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
Route 9 Corridor Study	Included analysis of intersection locations in Golden Triangle area of Framingham/ Natick; included recommendations for improvements, including Transportation Terminal	Work performed in late 1980s; approval of recommendations never voted by client agencies	FIG A-1, # 61
Worcester Commuter Rail Patronage Forecasts	Forecasts of ridership provided for environmental studies of service extension, with new stations between Worcester and Framingham	Work performed early 1990s for Draft EIR; project currently under construction	FIG A-1, # 67

D. Active/Pending CTPS Studies

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
Saxonville Rail Trail Feasibility Study	Identification of right-of-way issues, potential demand, potential connections, obstacles (similar to previous studies)	CTPS work scope approved by SSC (March 1999)	FIG 4-4, # 23
Underutilized Park-Ride Lot Study	Purpose of study is to evaluate factors which lead to low usage of existing MassHighway park-ride lots, recommend improvements. Includes lot on Flutie Pass.	Study approximately 70% complete (March 1999)	FIG 4-4, # 19
Commuter Rail Service to I-290, Northborough	Study to estimate ridership, costs of restoring Fitchburg Secondary commuter rail service	Study approved, underway	FIG 4-4, # 20

Table C-2 (cont'd) – Current Projects and Studies--Framingham

	Route 9/126 interchange	Development of redesign concepts for substandard interchange	Ongoing, as part of MassHighway 25 percent design efforts	FIG 4-4, #26

E. Additional Study Needs Identified

	LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
	Shuttle Bus Service Evaluation	Assistance requested to identify candidate routes for shuttle bus services serving the 9/90 and downtown Framingham areas, and evaluating such services	Review of employee survey data, identification of most likely routes/ destinations based on service criteria, and evaluation of potential ridership/ costs	FIG 5-1, # 2
	Route 126 (Framingham) traffic signal coordination	Rizzo made corridor intersection recommendations; next steps needed. Town would like to investigate a corridor signal strategy from Route 9 to south of Route 135.	Corridor-length signal timing study—6-7 signals	FIG 5-1, # 1
	"Reverse rail/bus commute" potential in MetroWest	Framingham and other MW towns believe there is potential for reverse commuting by transit modes to MetroWest industrial sites, would like help identifying scale and location of potential demand.	Study of existing reverse commuting/ shuttle users; extrapolation of demand	Areawide; not shown on FIG 5-1

TABLE C-3
Current Projects and Studies—MARLBOROUGH

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
63615	I-495 Interchange	New interchange construction south of Route 20 in Marlborough NOTE: Spring '99 TIP reports as "deleted" because construction underway	Advertised 1998	FIG 4-2, #8
600630	Rte. 20 (East) reconstruction	Roadway reconstruction	Under construction	FIG 4-2, # 9
601063	Interstate 290-Solomon Pond Rd. intersection	Reconstruction of ramp terminal intersection with Solomon Pond Road: new signals, channelization	Completed	FIG 4-2, # 10
600428	Rte. 20 (W. Main St.) reconstruction	Roadway widening, reconstruction	Deferred to FY2001 in Spring '99 update	FIG 4-2, # 28
601133	Rte. 20 (Boston Post Rd.) widening / reconstruction	Roadway widening, reconstruction	FY1999 project	FIG 4-2, # 27
--	Assabet Rail Trail	Creation of rail trail from railroad ROW	Included in FY1999 Enhancement appendix; developer funded design of one section	FIG 4-2, # 39
6870	Boundary St. reconstruction	Reconstruction and possible extension of Boundary Street	Not currently programmed	FIG 4-2, # 47

B. Locally Advanced and Developer-Sponsored Projects

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Industrial Access Road	City will build Industrial Access Road connecting Addition Hill area with Fitchburg Street and Route 85 Connector; funded with PWED grant (NOTE: one section of "Assabet Rail Trail"—see Section A)	Design (paid for by developer) is 75% complete, takings made.	FIG 4-3, #9
	Route 85 Connector / Fitchburg St. grade-separation	Marlborough and Hudson exploring ways to fund study of grade-separation here	Hudson turned down for TDM funding; towns still looking for funding. MassHighway will initiate study of potential improvements	FIG 4-3, #10
	Cedar Hill Street reconstruction	Street upgrade / reconstruction; new signals at Cedar Hill / Crane Meadow / D'Angelo Drive intersection	Construction funding from MWRA / developer.	FIG 4-3, #23
	Williams Street	Williams / Forest Street Intersection and street upgrade	Developer-funded upgrade	FIG 4-3, #24

Table C-3 (cont'd) – Current Projects and Studies—Marlborough

	Farm Road / Framingham Road	Safety improvement between Walker Street and Cook Lane including new drainage, curbing, geometric improvements	FIG 4-3, #25

C. Previous CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 20 Corridor Study	Full corridor study of Route 20, identified deficiencies, made improvement recommendations	Work performed 1988-91. Several recommendations currently being implemented	FIG A-1, # 60
	Marlborough West Area Study	Areawide study of anticipated development and associated needs for improvements; supported concept of new interchange on I-495	Work completed in late 1980s, prior to start of EIR for new Interchange	FIG A-1, # 65

D. Active/Pending CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Commuter Rail Service to I-290, Northborough via Marlborough	Interest expressed in restoring Fitchburg Secondary commuter rail service for "reverse commuting" as well as commuting to Boston Core. Study desired to estimate potential demand, capital and operating costs, and environmental impacts of proposed service	Approved work scope; analysis about to begin.	FIG 4-4, # 20
	Commuter bus improvements, Marlborough	MBTA starting new commuter bus services to / from Marlborough. Assistance sought in development of signs, route information.	Graphic design work performed 1998 / 99; CTPS will also evaluate performance of routes	FIG 4-4, # 24

E. Additional Study Needs Identified

	LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
	"Reverse rail / bus commute" potential in MetroWest	City believes there is potential for reverse commuting by transit modes to MetroWest industrial sites, would like help identifying scale and location of potential demand.	Study of existing reverse commuting / shuttle users; extrapolation of demand	FIG 5-1, # 4 (not shown)
	Route 85 (Marlborough) signal coordination	Signals located along Route 85 are uncoordinated, slow traffic movements—Lincoln, Union, Hudson Street signals all within a mile of each other, should be examined in conjunction with flanking signals	Signal timing coordination study	FIG 5-1, # 8

TABLE C-4
Current Projects and Studies—NATICK

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
110952	Rte. 30-Speen Street	Reconstruct and widen the intersection of Route 30 and Speen Street (Framingham / Natick)	Advertised in FY1998	FIG 4-2, # 7
601266	Pleasant St. Bridge	Rehabilitate the Pleasant Street Bridge (N-3-2) over the Sewer Canal.	Advertised in FY1997	FIG 4-2, # 11
--	Dennis Moran Park	Landscaping / improvements to Memorial Park, Downtown Natick	Construction completed	FIG 4-2, # 12
39360	Loker St. Bridge	Reconstruct the Loker Street Bridge over Conrail	Status unclear; to be clarified	FIG 4-2, # 13
--	Rte. 135, Phase 1 (Bicycle & Pedestrian Improvements)	New parking lot construction, landscaping in Phase I; Phase II includes pedestrian walkway along RR track. Funding through ISTEA	Local Enhancement project-- Phase I completed; Phase II not yet started	FIG 4-2, # 14
600573	Rte. 135	Reconstruct Route 135 (East Central Street and West Central Street) from the Wellesley town line to the Framingham town line.	In design by consultant to MassHighway District 3	FIG 4-2, # 29
	Natick Center	Pedestrian improvements in conjunction with new Town Hall / rail station	Local Enhancement project	FIG 4-2, # 41
602777	Rte. 27 Bridge over Rte. 9	Replace the Route 27 Bridge (N-3-20) over Route 9.	In design by consultant to MassHighway District 3	FIG 4-2, # 53
601586	Rte. 9	Make various improvements (e.g., milling, resurfacing, intersection improvements, etc.) on Route 9 from 1500 feet west of Oak Street (Natick) to 500 feet east of Woodside Street (Wellesley) (Oak St Intersection).	Not currently programmed	FIG 4-2, # 54

B. Locally Advanced and Developer-Sponsored Projects

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 9 at Oak Street / Apple Hill, Natick	Apple Hill access issues awaiting final disposition; tied to conceptual design for Oak Street intersection .	MassHighway jurisdiction; no obvious role for CTPS	FIG 4-3, # 20

C. Previous CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 9 Corridor Study	Included analysis of intersection locations in Golden Triangle area of Framingham / Natick; included recommendations for improvements, including Transportation	Work performed in late 1980s; approval of recommendations never voted by client agencies	FIG A-1, # 61

	Terminal		

Table C-4 (cont'd) – Current Projects and Studies—Natick

MassHighway Park/Ride Lot observations	Counts/observations over a 1-year period to identify usage patterns of park-ride lot	Work performed in 1996-97	FIG A-1, # 64
Logan Express relocation study	Evaluated alternative locations for relocated Logan Express bus terminal/parking lot	Work performed in 1989	FIG A-1, # 68
West Natick/Natick Center commuter rail parking analysis	Estimated demand for parking at several locations along commuter rail line in Natick, including site of pending MBTA garage	Work performed as part of areawide study of potential for expanded commuter rail parking	FIG A-1, #69

D. Active/Pending CTPS Studies

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
Saxonville Rail Trail Feasibility Study	Identification of right-of-way issues, potential demand, potential connections, obstacles	CTPS work scope submitted to SSC (March 1999)	FIG 4-4, # 23
Underutilized Park-Ride Lot Study	Purpose of study is to evaluate factors which lead to low usage of existing MassHighway park-ride lots, recommend improvements. Includes lot on Flutie Pass.	Study approximately 70% complete (March 1999)	FIG 4-4, # 19

E. Additional Study Needs Identified

LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
Route 9/ Route 27 Interchange, Natick	MassHighway currently designing bridge replacement only. Town would like to see larger project, addressing issues related to turning lanes, signals, access to abutting properties on Route 27 next to interchange	Circulation/ operations study of interchange area (along both Routes 9 and 27)	FIG 5-1, # 5
Natick Neighbor-hood Bus Use Study	Town currently has 2 buses, will receive another bus from Mass Highway for senior service; request help/advice in determining best ways to use these buses (routes, schedules, etc.)	Local transit marketing study	(not shown on Figure 5-1)

TABLE C-5
Current Projects and Studies—SOUTHBOROUGH

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
602001	Rte. 85 traffic signal	Install pedestrian signal in front of St. Mark's School	Advertised in FY1998	FIG 4-2, # 15
601621	Rte. 30 (Main St.)	Resurfacing	Advertised in FY1998	FIG 4-2, # 16

B. Locally Advanced and Developer-Sponsored Projects

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 9 Crossing study	Study of alternatives for connections across Route 9 near Parkerville Road (SEA, 1997); funded by Town	Vehicular crossings rejected in public meetings; preferred alternative is for pedestrian bridge only	FIG 4-3, # 11
	Route 30 at Firmin / Willow St	Intersection improvements associated with 9/90 mitigation	Ready for construction	FIG 4-3, # 26

C. Previous CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 9 Corridor Study	Included analysis of Southborough intersection locations to determine level of upgrading necessary to achieve LOS C; no physical feasibility analysis done	Work completed and draft report prepared in 1992; study never finalized	FIG A-1, # 61

D. Active/Pending CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	(None identified)			

E. Additional Study Needs Identified

	LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
	"Reverse rail/bus commute" potential in MetroWest	Interested in exploring potential for reverse commuting by transit modes to MetroWest industrial sites, would like help identifying scale and location of potential demand.	Study of existing reverse commuting / shuttle users; extrapolation of demand	Not shown on FIG 5-1
	Route 9 / Central Street area (Fayville) in Southborough	Chronic intersection congestion on approach to 9/90. Town wishes to keep Route 9 traffic from diverting to local streets. Fayville area residents opposed to Route 9 widening, improvements.	Development of conceptual alternatives for intersection improvements	FIG 5-1, # 7

TABLE C-6
Current Projects and Studies—SUDBURY

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
100801	Rte. 20-Concord Rd.	Signal upgrade	Advertised in 1997	FIG 4-2, # 17
601578	Rte. 20-Nobscot Rd.	Intersection improvements	Programmed for FY1999	FIG 4-2, # 30
--	Old Sudbury Rd.	Geometric/intersection improvements	Not currently programmed	FIG 4-2, # 48

B. Locally Advanced and Developer-Sponsored Projects

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 27-Concord Road	Intersection improvements	Town looking to acquire land to upgrade intersection	FIG 4-3, # 12

C. Previous CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 20 Corridor Study	Full corridor study of Route 20, identified deficiencies, made improvement recommendations	Work performed 1988-91. Several recommendations currently being implemented, including Nobscot Road intersection	FIG A-1, # 60

D. Active/Pending CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Accident warrants, 3 intersections	Town believes these are high-accident locations	Evaluate accident data (provided by Sudbury) at 3 intersections on Routes 117 and 20	FIG 4-4, # 27

E. Additional Study Needs Identified

	LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
	Route 20 Intersections at Horse Pond Road and Wayside Inn Road, Sudbury	Congested intersections in need of improvement. Town would like some conceptual design assistance	Development of conceptual alternatives for intersection improvements	FIG 5-1, # 14

TABLE C-7
Current Projects and Studies—WAYLAND

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
105121	Rte. 20 Bridge	Rehab of bridge over Sudbury River	Programmed for FY2000	FIG 4-2, # 31
105122	Rte. 20-Rte. 27/126 intersection	Intersection reconstruction with signal improvements	Deferred to FY2001	FIG 4-2, # 32
601579	Rte. 27-Rte. 30 intersection	Intersection improvements	Not currently programmed; Town will oversee design effort	FIG 4-2, # 55
602723	Pelham Island Rd. Bridge	Bridge replacement	Not currently programmed	FIG 4-2, # 56

B. Locally Advanced and Developer-Sponsored Projects

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
--	Route 30/ Rice Road	Intersection improvements	Town hired consultant to do redesign (funded by private developer); Town wants rebuilt to local standards	FIG 4-3, # 13
--	Route 30 Corridor Study	General traffic management study of Route 30 in Wayland (Friend, 1997), funded by Town	Study made recommendations for "traffic calming"-type improvements in Route 30 corridor	FIG 4-3, # 14
--	New Town Center Studies	Town has hired consultant (Office DA) to produce concept schemes for relocated town center, with revised street pattern, in conjunction with reuse of old Raytheon property.	Study underway.	FIG 4-3, # 15

C. Previous CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
--	Route 20 Corridor Study	Full corridor study of Route 20, identified deficiencies, made improvement recommendations	Work performed 1988-91. Several recommendations currently being implemented, including reconstruction of Route 20/27/126 intersection (see A. above)	FIG A-1, # 60

Table C-7 (cont'd) – Current Projects and Studies—Wayland

D. Active/Pending CTPS Studies

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
Signalized Intersection Study (5 intersections in MetroWest)	Towns were asked to identify isolated signalized intersections which they believe have faulty timing, other problems; includes intersection of Route 27 and Old Connecticut Path in Wayland	Observe intersection operations, perform traffic counts, suggest improvements in signal timing, geometrics	FIG 4-4, # 21

E. Additional Study Needs Identified

LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
(None identified at present)			

TABLE C-8
Current Projects and Studies—WELLESLEY

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
601800	Rte. 9 resurfacing (one section)	Roadway resurfacing	Completed	FIG 4-2, # 18
601620	Rte. 9-Lexington Rd. safety improvements	Install impact attenuators on Route 9 at Lexington Road	Completed	FIG 4-2, # 19
600712	Rte. 16 (Washington St.) reconstruction	Reconstruct / reclaim Route 16 from Grantland Rd to Newton City Line	Programmed for FY2000	FIG 4-2, # 33
602616	Rte. 9 (Worcester St.) reconstruction	Reconstruct Route 9 from Willow St to I-95 NB on-ramp	Under construction	FIG 4-2, # 34
125298	Rte. 9 drainage improvements (Boulder Brook)	Improve drainage along Route 9 at Boulder Brook culvert	Deferred to FY2002	FIG 4-2, # 35
601665	Woodlawn Ave. Bridge reconstruction	Reconstruct the Woodlawn Avenue Bridge over Conrail and the MBTA	Programmed for FY1999	FIG 4-2, # 36
86920	Rte. 128 Add-a-Lane	Add 2 general-purpose travel lanes in the median of Route 128 between Wellesley and Randolph	Programmed for FY1999 to 2004	FIG 4-2, # 37
602087	Rte. 16 (Washington St.) reconstruction	Reconstruct and resurface a section of Route 16 (west of Route 135)	Not currently programmed	FIG 4-2, # 49
600776	Rockland St. Bridge	Replacement of bridge over Conrail	Not currently programmed	FIG 4-2, # 57
94762	Rte. 16 Bridge rehabilitation (over Rte. 9)	Bridge rehabilitation, including relocation of retaining wall	Not currently programmed	FIG 4-2, # 58
602840	I-95 noise barriers	Install noise barriers along I-95 in Newton and Wellesley	Not currently programmed	FIG 4-2, # 61

B. Locally Advanced and Developer-Sponsored Projects

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 16 reconstruction	Town planning to reconstruct section not covered by TIP projects (between "Service Drive" and the Natick Town Line)	Chapter 90 funds will be used when available	FIG 4-3, #16
	MBTA parking fee structure	Town recently increased daily parking fee from $1 to $2, to discourage out-of-town parkers	Implemented January 1999.	(not shown)

Table C-8 (cont'd) – Current Projects and Studies—Wellesley

C. Previous CTPS Studies

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
Route 9 Corridor Study	Included analysis of Wellesley intersection locations to determine level of upgrading necessary to achieve LOS C; no physical feasibility analysis done	Work completed and draft report prepared in 1992; study never finalized	FIG A-1, # 61
Forecasts for Route 128 Add-a-Lane DEIR	CTPS prepared traffic forecasts for all Route 128 improvement alternatives, including a large number of HOV lane alternatives. Forecasts included LOS analysis of Route 9 ramps	Work performed in 2 phases: 1986-87 and 1992-95; Draft EIR submitted June 1996	FIG 4-2, # 37

D. Active/Pending CTPS Studies

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
Forest Street at Wellesley Avenue intersection, Wellesley	Main intersection serving Babson College, currently 4-way stop sign but becoming congested (1 of 5 intersections included in signalized intersection study)	Signal warrant analysis	FIG 4-4, # 21
Route 9 Corridor Study Update, Wellesley	Previous (1996) corridor study focused on Level-of-Service analysis, generalized recommendations, lacked information about physical constraints / feasibility	Revisit and update previous study, identify additional improvement options, include physical constraints	FIG 4-4, # 22

E. Additional Study Needs Identified

LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
Route 16 / Newton Lower Falls area	Circulation issues in this area related to Route 128 access, proposed developments (Stop & Shop)—area should be restudied with both Wellesley / Newton participation	Areawide circulation / traffic study	FIG 5-1, # 10
Cedar / Walnut / River Street Intersection, Wellesley	Reported to be a hazardous location—poor turning radii, poor visibility	Accident analysis / conceptual design for safety-related improvement	FIG 5-1, # 9
"Reverse rail / bus commute" potential in MetroWest	Wellesley and other towns believe there is potential for reverse commuting by transit modes to MetroWest industrial sites, would like help identifying scale and location of potential demand.	Study of existing reverse commuting / shuttle users; extrapolation of demand	Areawide; not shown on FIG 5-1

TABLE C-9
Current Projects and Studies—WESTON

A. Current TIP Projects

ID No	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
130375	South St. (River Rd.)	Replace bridge over Stony Brook in Waltham and Weston	Advertised in FY1999	FIG 4-2, # 20
601999	Rte. 117 (North Ave.) resurfacing (one section)	Resurface additional section of Route 117	Not currently programmed	FIG 4-2, # 50
602000	Rte. 30-Wellesley St.	Intersection safety improvements	Town hiring consultant to do conceptual study; programmed in FY 2002	FIG 4-2, # 38
602534	Recreation Rd. Bridge	Replace the Recreation Road Bridge over I-95 (Route 128).	Project at 75% design	FIG 4-2, # 59
110980	Rte. 30 Bridge deck rehabilitation	Rehabilitate the deck on the Rte. 30 (South Avenue) Bridge over the Charles River.	Not currently programmed	FIG 4-2, # 60

B. Locally Advanced and Developer-Sponsored Projects

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 20 at Bypass Road	Town looking at alternatives to traffic signal (proposed by MassHighway to solve Route 20 back-up problem)	Ongoing	FIG 4-3, # 18
	Route 117 Crosswalk	Town desires to locate crosswalk on Route 117 east of Church Street	Ongoing	FIG 4-3, # 19

C. Previous CTPS Studies

	LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
	Route 20 Corridor Study	Full corridor study of Route 20, identified deficiencies, made improvement recommendations	Work performed 1988-91. Several recommen-dations currently being implemented	FIG A-1, # 60
	Central Mass. Rail Trail Feasibility Study	Evaluation of potential for unused railroad right-of-way as bicycle / pedestrian trail	Work completed	FIG A-1, # 70
	Central Mass. Commuter Rail feasibility study	Evaluation of potential for commuter rail on unused railroad right-of-way	Work completed	FIG A-1, # 63
	Route 117 recon-naissance study	Response to request regarding accident experience and feasibility of scenic-route designation for Route 117	Work performed in 1997	FIG A-1, # 62

Table C-9 (cont'd) – Current Projects and Studies—Weston

D. Active/Pending CTPS Studies

LOCATION	PROJECT TYPE	STATUS TO DATE	MAP REF.
Wellesley St / Route 30	One of 5 locations being examined under signalized intersection study (mainly signal timing issues)	Project underway.	FIG 4-4, # 21

E. Additional Study Needs Identified

LOCATION	PROJECT TYPE	TYPE OF STUDY	MAP REF.
Route 20 / Bypass Road	Bypass Road operates as detour around existing Route 20 signal. Connections to / from Bypass Road cause congestion, queuing on Route 20. Town rejected MassHighway proposal for signalization	Analysis of interaction between Route 20 and Bypass Road; recommendations for improvements	FIG 5-1, # 12
I-95 / River Road / Route 30 intersection	Reported to be high-accident location	Accident review, possible analysis of improvements	FIG 5-1, # 13
Wellesley Street / Newton Street intersection	Outstanding weaving / merging issues remaining after recent (1998) reconstruction	Re-evaluation of merging / weaving operations, and recommendations for improvement	FIG 5-1, # 11

MEMORANDUM

TO: **MetroWest Files** **August 27, 1999**

FROM: **Alicia Powell Wilson**

RE: **MetroWest Subregional Area Study: Technical Memo #1: An Evaluation of Peak Hour Traffic Operations and Intersection Design at Wellesley and Newton Streets in Weston**

INTRODUCTION

In Phase I of the MetroWest Sub-Regional Area Study, CTPS staff interviewed town planners in each community of the MetroWest sub region to determine traffic and congestion problems. The planners were asked to nominate outstanding problems or issues that might be addressed during Phase II of the study.

During the meeting with the town of Weston, the chairman of the Weston Traffic Committee stated that in November 1998, the town reconfigured an island and made improvements at the intersection of Wellesley Street and Newton Street. The new configuration eliminated some of the many weaves and merges. Mr. Engler also indicated that there are still some merging and weaving problems at the intersection and that the town needs help with possible solutions. As a follow-up to this conversation, this intersection and the nearby one at Wellesley and School Streets (approximately 300 feet to the north) were observed during the morning peak hour on two occasions in mid June of this year. Traffic counts were collected on one of these occasions.

EXISTING CONDITIONS

Figure 1 shows the current intersection configuration along with current AM peak hour traffic counts. School Street is one lane in each direction and there is no traffic control at the southbound approach. Wellesley Street at School Street is one lane in each direction with a yield sign controlling southbound traffic. Wellesley Street northbound at Newton Street is controlled by a stop sign. The approach consists of one exclusive left turn lane and one exclusive right turn lane. The Newton Street approach is one lane wide and has no traffic control. The segment of road between the two intersections consists of two southbound lanes, one for Wellesley Street and one for Newton Street, and one northbound lane.

Table 1 shows the total and 15-minute traffic volumes between 7:30 to 8:30 AM for each approach. From the table and Figure 1, the highest volume is the northbound left turn at Wellesley Street. The combined traffic volume from this approach and that of Newton Street northbound proceeds downstream towards School Street. At that point traffic is split almost equally between School Street (presumably moving towards Route 20

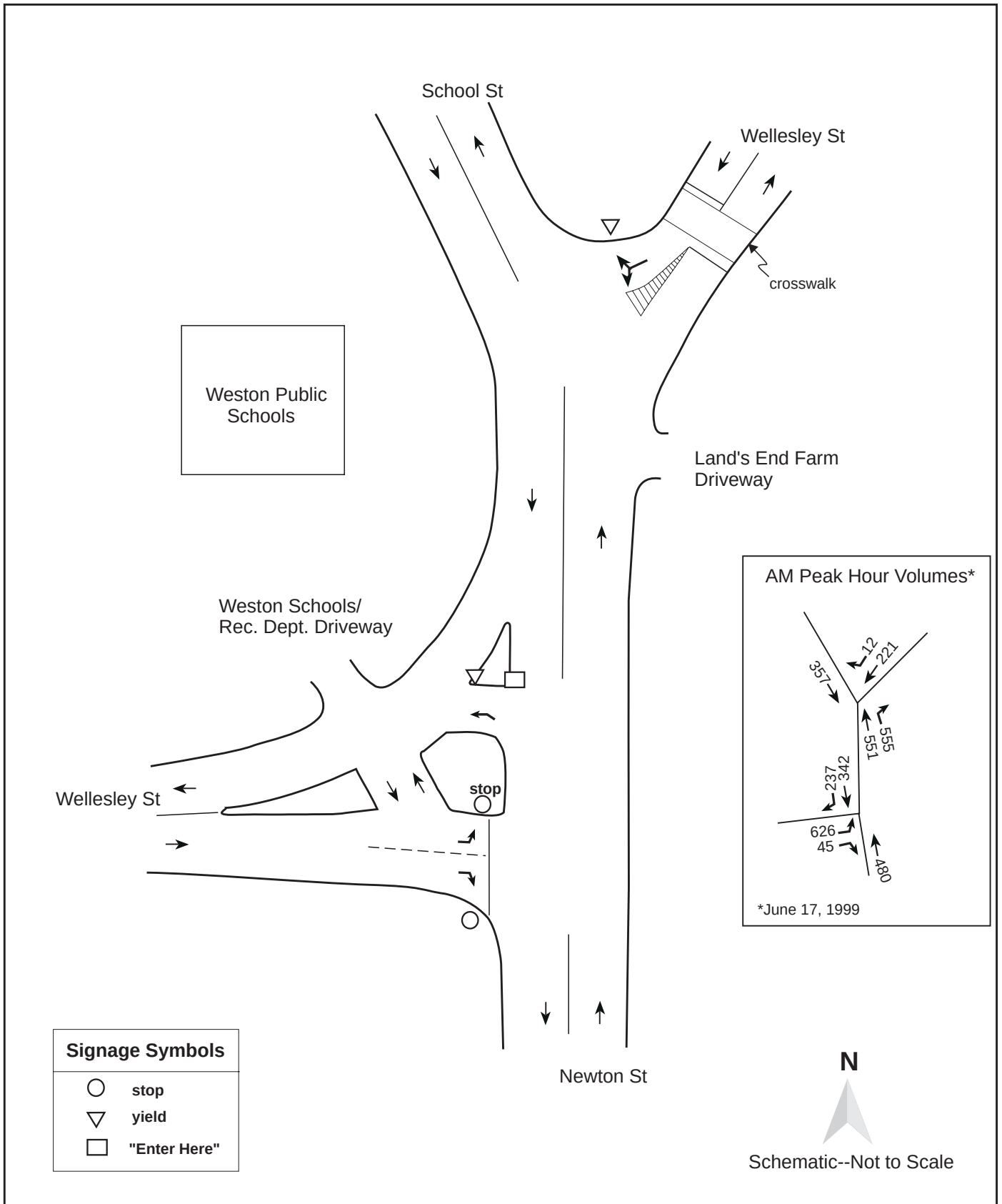


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Figure 1
Newton St/Wellesley St Intersection, Weston

MetroWest/P_Rt27Natick/graphics/port2.cdr

westbound and destinations north) and Wellesley Street (presumably moving towards Route 20 eastbound and destinations along Route 128). Vehicles southbound on Wellesley Street were tracked to see if they were headed southbound on Wellesley Street or southbound on Newton Street. The results are shown in Table 2. During the hour, 80% of these vehicles proceeded southbound on Wellesley Street and, presumably, on to Route 30 and Route 9. The opposite holds for the southbound School Street traffic. Eighty-four percent of these vehicles proceeded southbound to destinations along Newton Street or, presumably, Route 30, Route 128 or the Mass Pike.

In the morning when the counts were taken and before police officer control started at 7:45 AM, long queues were observed on the northbound Wellesley Street approach. The Wellesley Street traffic at School Street also appeared to move with some difficulty. All other movements seemed to proceed unimpeded through the intersections.

Traffic during the PM peak was observed on a later date. There appeared to be few problems with traffic flow during this time period. The heaviest flow is southbound from School Street to Wellesley Street. However, there is no opposing traffic for this movement. The longest queue occurs on the Wellesley Street southbound approach at School Street (10 to 12 vehicles at times). Vehicles on this approach have to yield to southbound School Street and northbound Wellesley / Newton Streets traffic. Since PM peak traffic was observed in early July, this period should be observed again in the fall when traffic is heavier.

A police officer directs traffic at the Wellesley Street / Newton Street intersection from 7:45-8:15 AM. It appears that delays and queues during this period are determined by the skill of the officer. On one observation day, traffic was directed such that queues and delays were minimal on all approaches. When the Wellesley Street northbound traffic became too long, this officer stopped both directions of the Newton Street traffic and allowed the Wellesley Street traffic to proceed disregarding the stop signs. After several seconds, when this action caused queue build-ups on the southbound Newton Street approach, he stopped the Wellesley Street traffic and allowed both directions of Newton Street to move. During this time he stayed in the middle of the intersection directing vehicles and encouraging drivers to move on which helped shorten the gaps between vehicles and traffic was moving faster through the intersection. The queue on the southbound approach to Newton Street was never long enough to block Wellesley Street southbound vehicles from entering the School Street / Wellesley Street intersection. While still longer than on other approaches, the northbound queue on Wellesley Street was markedly improved and, on most occasions, it was completely cleared.

On the other observation day, another officer only gave priority to the northbound Wellesley Street traffic when it became too long. The rest of the time he stepped out of the middle of the intersection and allowed traffic to function according to the priorities dictated by the posted sign controls. This approach appeared to be inefficient as it allowed the southbound School Street / Newton Street queue to block the southbound Wellesley Street approach at the School Street / Wellesley Street intersection. The queues on all approaches were longer on this day even though traffic was lighter than on the other observation day.

On the day that the officer exercised the preferable traffic control at Wellesley Street / Newton Street, his actions resembled the operation of an actuated traffic signal with a two-phase cycle. Planning analysis software was run to obtain the best timings for such a signal. The resulting optimum cycle is 60 seconds with 32 seconds of green time allotted to the northbound Wellesley Street approach and 22 seconds of green time for through traffic on Newton Street. Under this signal design, the intersection would operate at a level-of-service B, a better than acceptable level-of-service.

On the days of the observations, other than the long queue at Wellesley Street northbound, no unsafe operations were detected, even without officer control. Traffic from Newton Street northbound arrives at Wellesley Street in platoons (probably due to the traffic signal at Route 30). This phenomenon helps create gaps of sufficient length for Wellesley Street left turning vehicles. At the downstream intersection, the Wellesley Street southbound traffic benefits from these gaps also. Finally, the southbound School Street traffic has the right of way over Wellesley Street Southbound and can proceed unimpeded through the intersection.

CONCLUSIONS AND RECOMMENDATIONS

Island Configuration

The present island configuration at this complicated system of intersections in Weston appears to be the appropriate one for efficient traffic operations and safety. The Wellesley Street northbound approach meets Newton Street at a right angle. This design resulted in improved driver visibility of the Newton Street traffic by Wellesley Street drivers and, therefore, improvement in the recognition and choice of gaps in traffic. The stop-sign control further promotes the safe crossing of the two-lane Wellesley / Newton Street by northbound left-turning Wellesley Street drivers. The drawback to stop control is the long northbound queue at Wellesley Street. Without officer intervention, this queue is well over 300 feet long.

Officer Control

The presence of an officer is necessary at Newton and Wellesley Streets for safe and efficient operations. Undoubtedly, this practice should continue during the morning peak period. If the queue on Wellesley Street becomes too long and drivers' patience is challenged, drivers might start accepting unsafe gaps on Newton Street, resulting in accidents. The officer should keep short cycles (time elapsed between two successive allocations of right-of-way to the same traffic movement), about 60 seconds. Also, the officer should direct <u>all</u> movements, not just long Wellesley Street traffic queue and should pay attention to the build-up of the southbound Wellesley / Newton Streets traffic queue. Finally, it is recommended that the Weston police consider extending their presence at the intersection by 15 minutes (direct traffic until 8:30 AM, instead of until 8:15 AM.)

Further measures for consideration

A measure that would further improve operations at the intersection of Newton and Wellesley Streets would be to provide a double left turn lane at the Wellesley Street northbound approach and an additional lane along Wellesley / Newton Streets northbound between this location and the downstream intersection at School Street. Northbound vehicles at the Wellesley Street approach would then be distributed in two left turning lanes according to their respective destinations (School Street or Wellesley Street) and would proceed downstream in that lane utilization. None to minimal lane changes are anticipated. This strategy would practically eliminate the Wellesley Street queues. However, officer control during peak periods would still be necessary. This strategy, if considered further, would have to be evaluated for right of way availability.

Cc Lee Engler, Weston Traffic Committee
MetroWest Growth Management Committee
Ken Miller, MassHighway Planning
Mary McShane, CTPS
AW / aw

Table 1
Movements at the Wellesley Street/Newton Street and School Street/Wellesley Street Intersections, AM Peak Hour (in 15-minute increments)

	15-minute period ending at:				
Movement	**7:45 am**	**8:00 am**	**8:15 am**	**8:30 am**	**7:30-8:30**
Wellesley St. SB*	53	42	66	60	221
Newton St. SB	76	67	114	85	342
Wellesley St. SB**	41	43	76	77	237
Newton St. NB	69	138	137	136	480
Wellesley St. NB (Left turns)	136	191	149	150	626
Wellesley St. NB (Right turns)	11	7	14	13	45
School St. SB	64	66	125	102	357
Wellesley St. NB	102	173	132	148	555
School St. NB	103	156	152	138	549

* Wellesley Street at School Street
**Wellesley Street at Newton Street

TABLE 2
Southbound Movements from Wellesley and School Streets
AM Peak Hour (in 15-minute increments)

WELLESLEY ST SB	53	42	66	60	221
To Newton St. SB:	15 (= 28%)	8 (= 19%)	14 (= 21%)	6 (= 10%)	43 (= 19%)
To Wellesley St. SB:	38 (= 72%)	34 (= 81%)	51 (= 77%)	54 (= 90%)	177 (= 80%)
SCHOOL ST. SB	64	66	125	102	357
To Newton St. SB:	61 (= 95%)	59 (= 89%)	100 (= 80%)	79 (= 77%)	299 (= 84%)
To Wellesley St. SB:	3 (= 5%)	7 (= 11%)	25 (= 20%)	23 (= 23%)	58 (=16%)

MEMORANDUM

TO: **MetroWest Files** **March 30, 2000**

FROM: **Mary P. McShane**

RE: **MetroWest Subregional Area Study**
Tech. Memorandum #2: Traffic Signal Coordination on Route 126, Framingham

1. Introduction

In January 1997, the Phase I Report of a study of the Route 126 corridor in Framingham was completed and submitted to the Town by its consultants.[1] The study had been commissioned to provide alternatives for addressing congestion problems along Route 126. The study area extended from the intersection of Concord Street (Route 126) with Anzio Road in the north, through Downtown Framingham, to the area south of Winthrop Street; but with particular focus on the railroad grade crossing at the intersection of Routes 126 and 135, in Downtown Framingham. Much of the report focuses on alternatives for improving that grade crossing, including options for grade separation. In addition, the report provides operations analysis of the other intersections along Route 126, recommending minor improvements and installation of a closed-loop signal system connecting these intersections.

The present memorandum extends the analysis of the consultant report to investigate further the possibilities for improving operations along Route 126 through traffic signal coordination between Anzio Road and Downtown Framingham. It is our understanding that the Route 126/135 grade crossing signals will be reconstructed as part of the Worcester Extension relocation of the Framingham rail station; and that the possible grade-separation of the tracks at this location is a long-term project at best. In the interim, it is worth examining the potential for relieving the existing queues, both northbound and southbound, between the downtown and Route 9 through signal modification.

2. Study Area

The study area for this analysis was taken to be the length of Concord Street (Route 126) in Framingham between a location north of Anzio Road near the interchange with Route 9, and Hartford Street in Downtown Framingham. This section includes the following signalized intersections:

[1] "Route 126 Corridor Study, Phase I—Alternatives Assessment", prepared for the Town of Framingham by Rizzo Associates, Inc., January 1997.

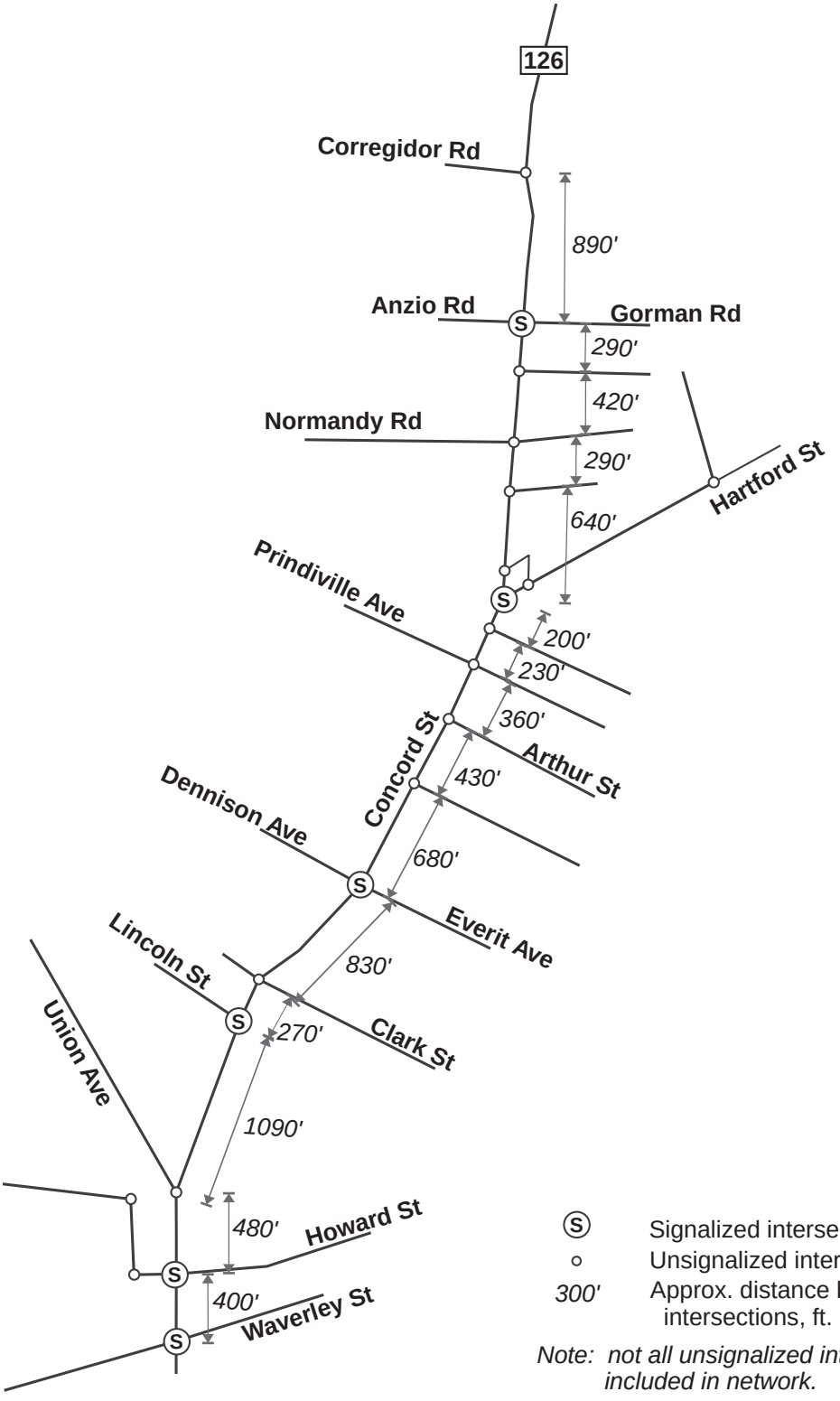
Anzio Road / Gorman Road
Hartford Street
Dennison Avenue / Everit Avenue
Lincoln Street
Howard Street

All signalized intersections appear to be independently timed, except for Howard Street, which is coordinated with traffic signals at the railroad track in Downtown Framingham. Data was obtained for the Concord / Howard Street intersection, along with the other signalized intersections. However, operations at this intersection are necessarily governed by the frequent grade crossing events which occur in the downtown. It may not be possible to provide signal progression through this location and southwards, so Howard Street was considered to be the southerly limit of the study area.

Likewise on the northerly end of Concord Street, congested operations at the unsignalized interchange of Route 126 with Route 9 may limit the practicality of signal progression north of Anzio Road; so that Anzio Road was assumed to be the northerly limit of the analysis.

In addition to the signalized intersections along Concord Street, the unsignalized intersection of Concord Street and Union Avenue was also included in the analysis. This location is the junction of two major north-south roadways in Downtown Framingham, serving relatively high volumes and located directly in front of Memorial Hall, the Town's municipal building; the intersection is commonly referred to as Memorial Square. This intersection operates as a small-scale roundabout, with a wide area of pavement having no lane designations, and no stop sign, yield or other control on its approaches (except for crosswalks and "yield to pedestrians" signs). It is possible that at some point this location may be signalized—signalization of Concord Street and Union Avenue was one of the recommendations of the Route 126 Corridor Study.

Also, because block lengths in this area tend to be short, Concord Street has numerous other unsignalized intersections between Anzio Road and Howard Street. Almost all of these intersections represent predominantly residential streets, which provide many opportunities for local residents, as well as employees of the Dennison factory complex and other industrial sites, to bypass chronic Concord Street queues by using parallel streets (e.g., Grant Avenue and Dennison Avenue). Most of these intersections are unlikely ever to be signalized, because exiting vehicles can utilize gaps in Concord Street traffic caused by the signals already in place. These unsignalized intersections *were* included in the network for Synchro analysis, even though Synchro itself doesn't model such intersections analytically. The companion simulation module (SimTraffic) *does* model unsignalized intersections. Such intersections represent a source of added friction along the Concord Street corridor, and contribute to delays experienced by drivers at locations other than the signalized intersections; consequently, we felt it was important to include them. **Figure 1** illustrates the network used for the analysis, and shows the approximate distances between intersections in feet.



CTPS
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Figure 1
Route 126 Corridor, Framingham: Network for Synchro Analysis

3. Methodology

3.1. Traffic Counts

In order to initiate the analysis, recent traffic counts were obtained from previous consultant studies,[2] and additional AM and PM peak-period counts were conducted in September 1999 at several locations:

Concord Street at Anzio Road / Gorman Road
Concord Street at Hartford Street
Concord Street at Everit Street / Dennison Street (partial count)

Counts were adjusted as needed to reconcile some inconsistencies with earlier volume estimates. The resulting 1999 traffic volumes are shown in **Figures 2** and **3**.

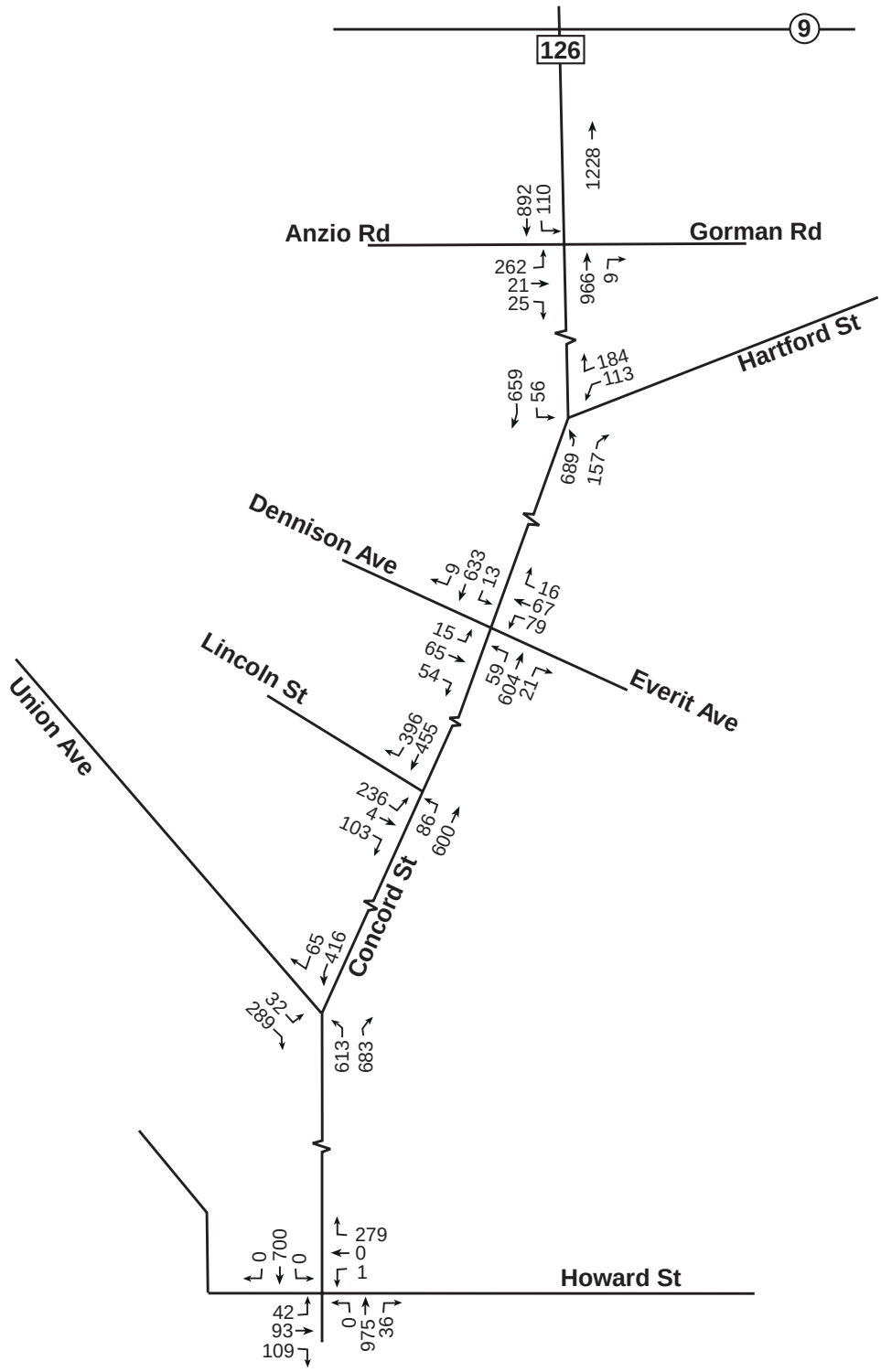
3.2. Queue Measurements

It is worth noting that traffic counts represent the volumes which actually *pass by* a given location. At intersections where long queues and queue backups impede movement, the rate of traffic flow will be reduced below the level it would normally reach under free-flow conditions. Standard capacity analysis does not recognize and account for such constrained operation, however; and will yield unreasonably good Level of Service results at locations where problems are obvious to the observer.

In comparison, analysis of intersection queues produces results which correspond more directly with intersection observations, and which yield greater insight into potential remedial measures. Field observations were undertaken at all signalized intersections to obtain information about queue lengths on each approach. Queues were measured for the longest lane in each lane-group, for a period of 10 signal cycles on each approach. The queue length recorded for each lane-group was generally the number of vehicles stopped at the light at the point when the red phase changed to green. For longer queues, an increment was included for vehicles which joined the back of the queue after the green phase had begun, but before the last queued vehicle had started to move. For very long queues (typically more than 15 vehicles), the difficulty of measuring the queue length increases, and the corresponding reliability of the queue measurement is reduced, because:

(i) the queue may extend beyond the limit of view; and,
(ii) the start-up shock wave travels back so far that "new" vehicles are actually joining the back of a moving queue.

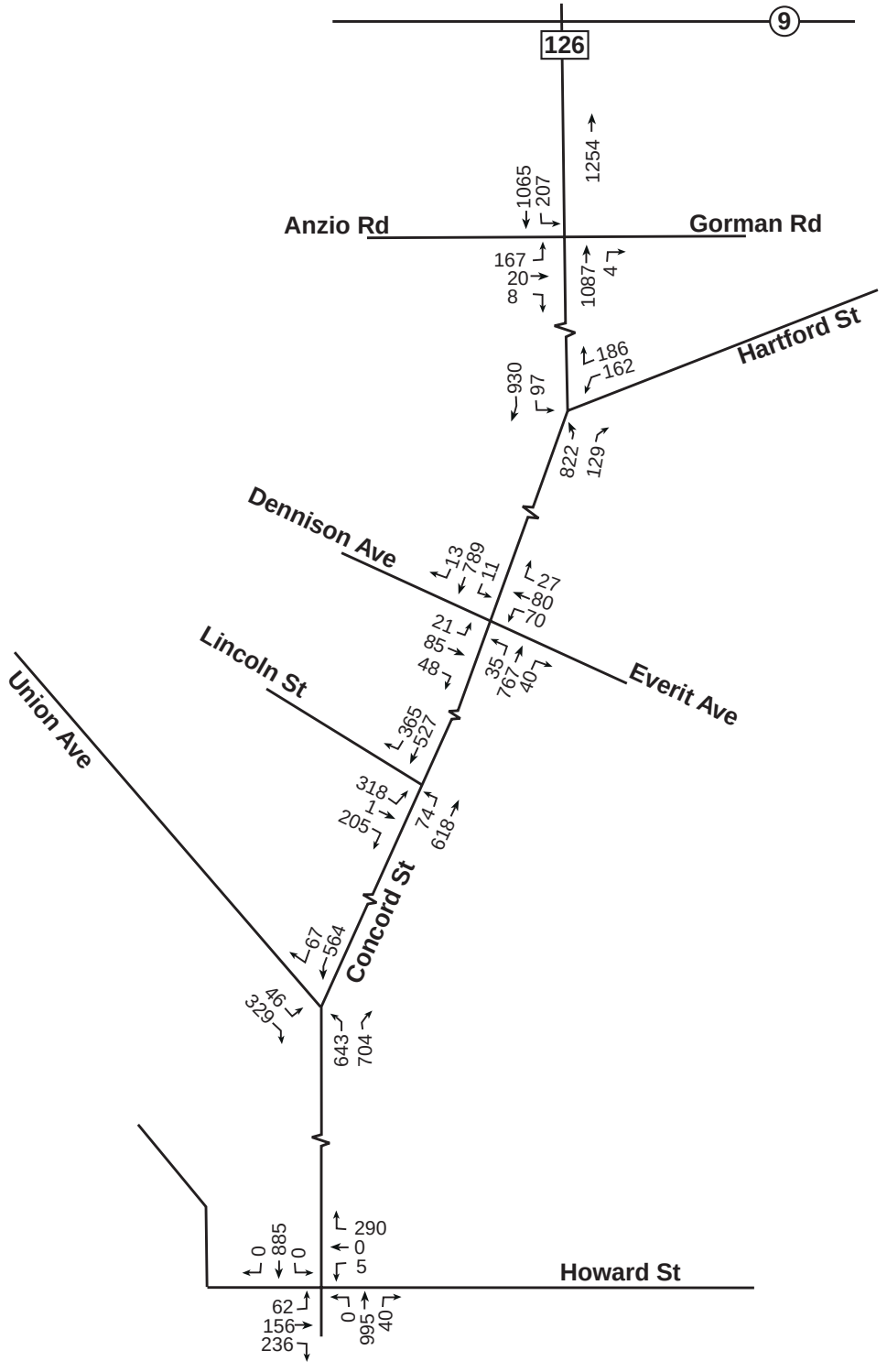
[2] "Route 126 Corridor Study," January 1997 (cited above); "ADESA Auto Auction Transportation Study", prepared for Town of Framingham by McDonough & Scully Inc., 1995; and MassHighway counts for Route 126, October 1998.



(Based on *Route 126 Corridor Study*, Prepared for Framingham Planning Department by Rizzo Associates, January 6, 1997, with additional counts, September 1999)

CTPS
MetroWest Subregional Area Study

Figure 2
Existing Traffic Volumes, 1999 AM Peak Hour



(Based on *Route 126 Corridor Study*, Prepared for Framingham Planning Department by Rizzo Associates, January 6, 1997, with additional counts, September 1999)

CTPS
MetroWest Subregional Area Study

Figure 3
Existing Traffic Volumes, 1999 PM Peak Hour

No attempt was made to count queue lengths greater than about 30-32 vehicles at any location. The observations on each approach were averaged, and converted to distances assuming an average length of 25 feet per vehicle. The resulting average queue lengths on each approach are shown in **Tables 1** and **2** for AM and PM Peak Hour respectively. All queue data collected is included in **Appendix A.**

3.3. Signal Timing

Field observations were made to obtain intersection geometry and signal timing patterns actually operating at each signalized intersection. The Anzio Road, Hartford Street, Dennison/Everit Avenue, and Lincoln Street intersections all have semi-actuated operation, with detector loops on the minor streets. Up to 10 cycles were observed during each peak period, and cycle lengths and phase times recorded for each intersection. Phasing at the Anzio Road and Hartford Street intersections could be observed simultaneously from vantage points north and south of these two intersections; the simultaneous observation confirmed that these two intersections have different cycle lengths, and are not coordinated. Neither do the other corridor intersections appear to have coordinated timing, although no other pair was observed simultaneously. The average phase times, and order in which phases are called, were determined for each intersection during each period; the resulting phasing and timing patterns are summarized in **Figure 4**. These patterns were used by the progression analysis methods to calculate estimated queue lengths for existing conditions; the calculated queue lengths could then be compared with the queues actually observed.

In addition, current signal permits were obtained where available for each signal. Permit timings were updated after consultation with the Framingham Fire Department officer responsible for traffic signals.

3.4. Analysis

The analysis used several software programs designed to analyze existing operations and determine optimal signal timing configurations along arterials such as Route 126:

- Synchro[3], for optimizing individual signals and signal groups;
- the Highway Capacity Software, Version 2.4g, which incorporates the methods of the 1994 Highway Capacity Manual for signalized Level of Service analysis;
- the MassHighway queue analysis spreadsheet based on the methods of Rahmi Akçelik, for computing queue lengths.

It is useful to compare the results of the two queue analysis methods (Synchro and Akçelik) to each other, and to the results of field-measured queues on each approach: the two are not identical, and the resulting queues are not easily verifiable by field measurements under congested conditions, for the reasons listed in Section 3.2 above.

[3] Initially, runs were performed using Synchro 3.2, but these were repeated when a later version of Synchro (4.0) became available. The results given by the two versions varied slightly. Tables 1 and 2 reflect the "existing conditions" analysis using Synchro 3.2, but the remaining tables have been added or revised to incorporate the results of the latest Synchro runs, using Synchro 4.0.

TABLE 1
Existing Route 126 Intersections:
AM Peak Hour with Existing Signal Timing

Intersection-- Route 126 (Concord St) at:	Field-Measured Queues (Fall 1999)		Analysis Results							
			Synchro				HCS / MassHighway Queue Method			
	Cycle length, sec.	Avg. Queue, ft	Overall LOS (delay, sec.)	Lane Group LOS	50th %-ile Queue, ft	95th %-ile Queue, ft	Overall LOS (delay, sec.)	Lane Group LOS	Average Queue, ft	95th %-ile Queue, ft
1. Anzio Rd/ Gorman Rd	114		C (24.2)				C (18.9)			
Anzio EBL		210		E	210	446*		D	204	378
Anzio EBT		22		D	31	80		C	30	67
Concord SBL		17		B	42	128		C	102	208
Concord SBT		285		B	482	908		B	557	858
Concord NBT		547		D	773	1401*		C	851	1237
2. Hartford Street	76		B (9.7)				B (9.6)			
Hartford WBL		43		C	50	125		B	53	113
Hartford WBT		63		B	72	145		B	85	176
Concord NBT		707		B	271	729*		B	332	564
Concord NBR		0‡		B	41	125		B	49	106
Concord SBL		15		A	10	31		B	29	65
Concord SBT		130		A	178	426		B	238	430
3. Dennison Ave/ Everit Ave	64		B (10.0)				B (8.8)			
Dennison EBT		18		C	36	84		B	34	75
Dennison EBR		0‡		C	24	62		B	23	51
Everit WBL		53		C	36	86		B	34	75
Everit WBT		0‡		C	37	86		B	35	78
Concord SBT		110		A	128	475		A	177	336
Concord SBR		0‡		A	1	9		A	1	3
Concord NBT		235		A	196	689*		B	286	499
Concord NBR		0‡		A	2	15		A	3	7

Table 1 (cont'd)

4. Lincoln Street	72		B (7.1)				B (9.7)			
Lincoln EBL		90		C	107	210		B	102	209
Lincoln EBR		8‡		B	43	97		B	40	89
Concord NBL		2		A	27	81		C	54	116
Concord NBT		93		B	168	379		B	255	455
Concord SBT		55		A	112	247		B	170	324
Concord SBR		0‡		A	99	227		B	149	290
5. Union Avenue (not signalized—not analyzed by Synchro)										
6. Howard Street	90		C (16.9)				C (19.7)			
Howard EB		80		C	69	122		C	71	140
Howard WB		110‡		D	182	386*		E	222	406
Concord NB		235		B	276	425		C	303	464
Concord SB		163		B	166	255		B	178	301

* 95th percentile queue exceeds capacity (Synchro); value shown represents queue after 3 minutes.

§ 50th percentile queue exceeds capacity (Synchro); queue is theoretically infinite.

‡ "Right-turn-on-red" represents frequent movement on this approach; therefore, right turns queues shorter than predicted by models.

NOTE: Howard Street signal closely related to other nearby intersections, including signals at RR track and Route 135. Therefore, NB and SB queue measurements not independent, not necessarily related to total hourly approach volumes.

TABLE 2
Existing Route 126 Intersections:
PM Peak Hour with Existing Signal Timing

Intersection-- Route 126 (Concord St) at:	Field-Measured Queues (Fall 1999)		Analysis Results							
			Synchro				HCS / MassHighway Queue Method			
	Cycle length, sec.	Avg. Queue, ft	Overall LOS (delay, sec.)	Lane Group LOS	50th %-ile Queue, ft	95th %-ile Queue, ft	Overall LOS (delay, sec.)	Lane Group LOS	Average Queue, ft	95th %-ile Queue, ft
1. Anzio Rd/ Gorman Rd	107		D (26.7)				C (20.2)			
Anzio EBL		117		D	113	234*		D	114	230
Anzio EBT		13		D	17	52		C	17	38
Concord SBL		80		F	121§	273*		F	225	410
Concord SBT		265		B	451	1096		B	548	847
Concord NBT		495		D	686	1392*		C	831	1211
2. Hartford Street	77		B (11.4)				B (13.2)			
Hartford WBL		58		C	74	175		C	73	154
Hartford WBT		55		B	77	154		B	80	166
Concord NBT		770		C	358	844*		C	431	695
Concord NBR		0‡		B	34	95		B	38	82
Concord SBL		53		A	16	55		B	50	108
Concord SBT		380		B	306	718		B	421	682
3. **Dennison Ave/ Everit Ave**	63		B (11.4)				B (6.8)			
Dennison EBT		38		B	39	91		C	44	97
Dennison EBR		0‡		B	17	48		B	19	43
Everit WBL		0‡		B	25	66		C	29	64
Everit WBT		28		B	39	90		C	44	96
Concord SBT		220		B	208	610*		A	213	393
Concord SBR		0‡		A	2	11		A	2	4
Concord NBT		115		C	261	703*		B	251	449
Concord NBR		0‡		A	6	24		A	6	13

Table 2 (cont'd)

4. Lincoln Street	72		B (7.7)				B (8.5)			
Lincoln EBL		105		B	127	243		B	138	272
Lincoln EBR		0‡		B	76	156		B	83	173
Concord NBL		35		B	17	96*		D	47	101
Concord NBT		103		B	165	432		B	240	433
Concord SBT		135		B	130	334		B	188	354
Concord SBR		0‡		B	83	222		A	18	41
5. Union Avenue (not signalized—not analyzed by Synchro)										
6. Howard Street	90		D (28.4)				D (27.2)			
Howard EB		118		D	159	295*		E	198	327
Howard WB		128‡		F	207§	442*		F	281	493
Concord NB		195		B	280	432		B	285	441
Concord SB		410		B	222	341		B	227	366

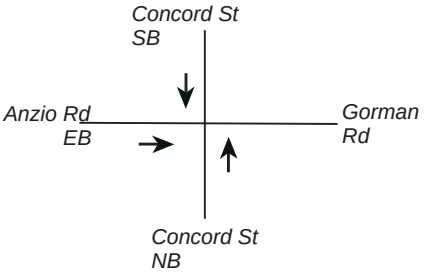
* 95th percentile queue exceeds capacity (Synchro); value shown represents queue after 3 minutes.

§ 50th percentile queue exceeds capacity (Synchro); queue is theoretically infinite.

‡ "Right-turn-on-red" represents frequent movement on this approach; therefore, right turns queues shorter than predicted by models.

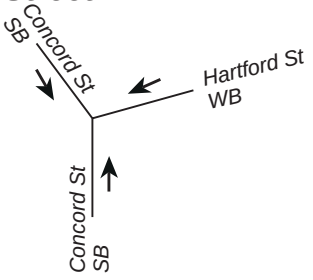
NOTE: Howard Street signal closely related to other nearby intersections, including signals at RR track and Route 135. Therefore, NB and SB queue measurements not independent, not necessarily related to total hourly approach volumes.

Concord Street at Anzio Road/Gorman Road



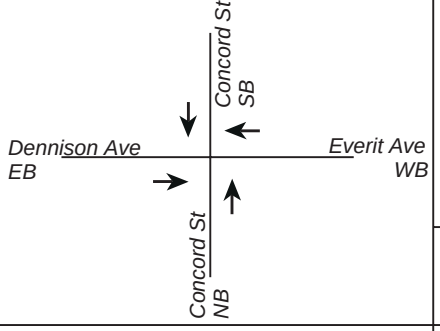
	①	②	③	Total Cycle:
AM:	G: 30 Y: 3	G: 8 Y: 0	G: 70 Y: 3	114 sec.
PM:	G: 22 Y: 3	G: 10 Y: 0	G: 69 Y: 3	107 sec.

Concord Street at Hartford Street



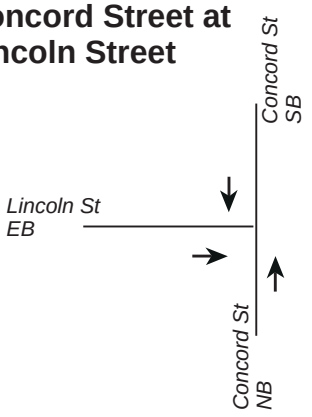
	①	②	③	Total Cycle:
AM:	G: 8 Y: 0	G: 40 Y: 3	G: 22 Y: 3	76 sec.
PM:	G: 8 Y: 0	G: 40 Y: 3	G: 24 Y: 2	77 sec.

Concord Street at Everit/Dennison Avenue



	①	②	Total Cycle:
AM:	G: 13 Y: 3	G: 45 Y: 3	64 sec.
PM:	G: 11 Y: 3	G: 46 Y: 3	63 sec.

Concord Street at Lincoln Street



	①	②	Total Cycle:
AM:	G: 26 Y: 4	G: 40 Y: 2	72 sec.
PM:	G: 26 Y: 4	G: 40 Y: 2	72 sec.

CTPS
MetroWest Subregional Area Study

Legend:

G: 26 phase green time
Y: 4 phase yellow time
All times in seconds.

Figure 4
Existing Phasing/Timing at Signalized Intersections

Geometry, volumes and signal timings were entered into Synchro, and analyzed as an uncoordinated system of independent intersections, reflecting existing conditions. Synchro produces a report organized by intersection, which gives Levels of Service, calculated delays, and both 50th and 95th percentile queue lengths for each intersection, along with other evaluation measures as desired.

In addition, Synchro allows individual intersection data to be translated into the form used by the Highway Capacity Software (HCS), Version 2.4g, for signalized intersection Level of Service analysis. The HCS allows refinement of individual intersection characteristics, including incorporation of limited pedestrian calls averaged over the analysis period, and other features. In turn, the HCS output can be read into the MassHighway queue analysis spreadsheet[4]. This spreadsheet calculates average and 95th percentile queues, using the methods developed by Akçelik[5].

4. Existing Condition Analysis Results

In **Tables 1** through **4**, the queues calculated by Synchro are compared with the measured or observed queues for each intersection approach. **Tables 1 and 2** represent the results of the first set of runs, using a simplified network which excluded most of the unsignalized intersections along Concord Street with the earlier version of the Synchro program (Version 3.2). **Tables 3 and 4** show results using the later version (Synchro 4.0) with a more detailed network which included many unsignalized intersections so that the simulation module of Synchro (Simtraffic) could model more accurately the turbulence created by entering and exiting side-street traffic. Synchro 4.0 is also based on the 1997 version of the Highway Capacity Manual analysis procedures; this accounts in part for some of the observed differences in the analysis of existing conditions.

A degree of variability can be seen in the queue lengths reported: the values tend to be fairly close to (i.e., within a car length of) the measured values for shorter queues. However, at longer queue lengths, both the Synchro analysis, and the HCS/Akçelik analysis tend to yield estimates which are higher, sometimes substantially higher, than the measured queue lengths, primarily for the reasons discussed above.[6] In addition, lanes which are not designated exclusive right-turn lanes may nevertheless serve largely right-turning traffic, and may permit a lot of right-turn-on-red movements which are not counted in the measured queue length. In this study, vehicles turning right on a red light were not excluded from the volume counts for some approaches; so the queues reported for these approaches may be overestimated. The lane groups with substantial right-turn-on-red activity are flagged in the Tables with daggers (†).

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[4] Note: Both Synchro 3.2 and HCS 2.4g are based on the 1994 version of the Highway Capacity Manual for signalized intersections. Synchro 4.0 is based on the 1997 version of the Highway Capacity Manual procedure.

[5] MassHighway Queue Length Analysis Spreadsheet, Version 2.5, based on Rahmi Akçelik, SIDRA Model (no date).

[6] i.e., difficulty in measuring queues which extend a long distance away from the stop light, and difficulty in determining where is the end of a long queue whose last vehicles are moving slowly, never fully stopped.

TABLE 3
Existing Route 126 Intersections:
AM Peak Hour with Existing Signal Timing
(Run on Synchro 4)

Intersection-- Route 126 (Concord St) at:	Field-Measured Queues (Fall 1999)		Analysis Results			
			Synchro 4.0			
	Cycle length, sec.	Avg. Queue, ft	Overall LOS (delay, sec.)	Lane Group LOS	50th %-ile Queue, ft	95th %-ile Queue, ft
1. Anzio Rd/ Gorman Rd	114		B (18.8)			
Anzio EBL		210		D	198	336*
Anzio EBT		22		B	13	46
Concord SBL		17		C	34	133*
Concord SBT		285		A	384	550
Concord NBT		547		B	563	795
2. Hartford Street	76		A (7.2)			
Hartford WBL		43		C	44	88
Hartford WBT		63		A	0	47
Concord NBT		707		A	176	371
Concord NBR		0‡		A	0	5
Concord SBL		15		A	5	18
Concord SBT		130		A	90	227
3. Dennison Ave/ Everit Ave	64		A (7.0)			
Dennison EBT		18		C	29	63
Dennison EBR		0‡		A	0	26
Everit WBL		53		C	29	66
Everit WBT		0‡		B	24	58
Concord SBT		110		A	105	231
Concord SBR		0‡		A	0	0
Concord NBT		235		A	96	193
Concord NBR		0‡		A	0	0
4. Lincoln Street	72		A (9.7)			
Lincoln EBL		90		B	56	135
Lincoln EBR		8‡		A	0	32
Concord NBL		2		B	20	46
Concord NBT		93		B	179	282
Concord SBT		55		B	121	103
Concord SBR		0‡		A	0	0
5. Union Avenue (not signalized—not analyzed by Synchro)						

Table 3 (cont'd)

6. Howard Street	90		B (16.4)			
Howard EB		80		B	35	72
Howard WB		110‡		A	0	76
Concord NB		235		B	253	330
Concord SB		163		B	152	203

* 95th percentile queue exceeds capacity (Synchro); value shown represents queue after 3 minutes.

§ 50th percentile queue exceeds capacity (Synchro); queue is theoretically infinite.

‡ "Right-turn-on-red" represents frequent movement on this approach; therefore, right turns queues shorter than predicted by models.

NOTE: Howard Street signal closely related to other nearby intersections, including signals at RR track and Route 135.
Therefore, NB and SB queue measurements not independent, not necessarily related to total hourly approach volumes.

TABLE 4
Existing Route 126 Intersections:
PM Peak Hour with Existing Signal Timing
(Run on Synchro 4)

Intersection-- Route 126 (Concord St) at:	Field-Measured Queues (Fall 1999)		Analysis Results Synchro 4			
	Cycle length, sec.	Avg. Queue, ft	Overall LOS (delay, sec.)	Lane Group LOS	50th %-ile Queue, ft	95th %-ile Queue, ft
1. Anzio Rd/ Gorman Rd	107		B (17.2)			
Anzio EBL		117		D	113	219*
Anzio EBT		13		C	12	38
Concord SBL		80		D	98	212*
Concord SBT		265		A	294	446
Concord NBT		495		B	583	943*
2. Hartford Street	77		B (10.6)			
Hartford WBL		58		C	61	113
Hartford WBT		55		A	0	46
Concord NBT		770		B	223	545*
Concord NBR		0‡		A	0	4
Concord SBL		53		A	10	45
Concord SBT		380		A	176	454
3. **Dennison Ave/ Everit Ave**	63		A (7.6)			
Dennison EBT		38		C	40	84
Dennison EBR		0‡		A	0	26
Everit WBL		0		C	27	63
Everit WBT		28		B	32	75
Concord SBT		220		A	157	314
Concord SBR		0‡		A	1	0
Concord NBT		115		A	129	219
Concord NBR		0‡		A	0	24
4. Lincoln Street	72		B (10.3)			
Lincoln EBL		105		B	82	185
Lincoln EBR		0‡		A	0	63
Concord NBL		35		B	17	42
Concord NBT		103		B	188	295
Concord SBT		135		B	149	233
Concord SBR		0‡		A	0	0
5. Union Avenue (not signalized—not analyzed by Synchro)						

Table 4 (cont'd)

6. Howard Street	90		B (16.5)			
Howard EB		118		B	63	122
Howard WB		128‡		A	3	82
Concord NB		195		B	234	307
Concord SB		410		B	200	262

* 95th percentile queue exceeds capacity (Synchro); value shown represents queue after 3 minutes.

§ 50th percentile queue exceeds capacity (Synchro); queue is theoretically infinite.

‡ "Right-turn-on-red" represents frequent movement on this approach; may be overestimated by queuing model.

NOTE: Howard Street signal closely related to other nearby intersections, including signals at RR track and Route 135.
Therefore, NB and SB queue measurements not independent, not necessarily related to total hourly approach volumes.

It is worth noting that Synchro 4.0 appears to give queue estimates which match more closely with observed values than Synchro 3.2, and also allows right-turns-on-red to be incorporated more realistically.

As noted above, the cycle length for the Concord / Anzio Road signal is considerably longer than that at Hartford and the other intersections to the south (107-114 seconds on average, compared with 60-80 seconds at the other intersections, and 90 seconds at Howard Street). Approximately 61 percent of this long cycle (70 seconds) is available to northbound through traffic in the morning, and 64 percent (69 seconds) in the evening. A slightly higher percentage of "green-time" is provided to southbound traffic, because of the 8-10 seconds of advance green provided to this movement. In spite of the preference given to major-street traffic, this location still experiences moderate-to-lengthy queues during both peak periods.

Concord / Hartford Streets also experiences long queues, particularly for Concord Street Northbound. On this approach, observed queues in both peak periods were represented more accurately by the 95th percentile queues calculated by both methods, than by the calculated average queues. This is partly attributable to tailbacks of stopped northbound traffic at the Anzio Road intersection, and partly to turbulence or interference of traffic entering from side-streets; but these two factors hardly explain the large differences between observed and estimated average queue length values.

At the Concord / Everit / Dennison and Concord / Lincoln Street intersections, the calculated queue lengths are quite consistent with the observed values, particularly for the Synchro analysis. The largest variations between calculated and observed values again occur for the Concord Street northbound approach; but the averages don't differ by more than 1-2 car lengths. At these two locations, there is ample opportunity for right-turning traffic to move on the red light, a condition which was not corrected for in the analyses. Therefore, in this analysis, the queues on the relevant approach lanes are over-estimated by the two programs. It would be possible to adjust the approach volumes to account for right-turn-on-red, based on additional field observations; presumably, the resulting calculated queues would then match more closely the observed values.

As mentioned earlier, the results of both observations and analysis at the Concord / Howard Street intersection are included here for comparison. However, they can not be evaluated or interpreted in the same way as the other results, because of the special conditions prevailing at this intersection; i.e., existing interconnection with the signals at the railroad track and at Route 135, and frequent pre-emption of traffic signals by railroad operations.

Despite the limitations of the *absolute values* calculated by the Synchro and Akçelik methods, the queue analysis procedures provide useful guidance about the potential for queuing on approaches serving moderate-to-high traffic volumes. In particular, these procedures may provide information on the *relative* impacts of alternative signal timing patterns and roadway configurations, as long as existing conditions are first validated with field measurements to provide a base case for the comparison. This was the

approach applied for the current study. The Synchro 4.0 queuing results appear to replicate existing conditions most accurately among the models tested.

5. Alternatives Examined

The objective of the exercise was to evaluate whether or not coordination of traffic signal timing could improve the flow along Route 126 in both directions, by reducing the queues and delays experienced by vehicles at present. The alternatives selected for analysis therefore did not assume major changes in roadway geometry, with one exception as described below. The two classes of alternatives examined were:

- coordination of existing signals only
- signal coordination plus other changes, including additional signals and geometric changes

5.1. Existing Signals with Timing Coordination Only

Synchro 4.0 was used to develop coordinated signal timing patterns along Concord Street between Anzio Road and Howard Street. The Synchro method identifies and groups intersections in a corridor which are most suitable for coordination, and selects cycle lengths and offsets in order to maximize two-way progression within groups. The combinations studied included the following:

ALTERNATIVE 1: Existing intersection geometry, AM and PM Peak Hour signal timing optimized using Synchro, with a common cycle length selected for corridor (70 seconds).

ALTERNATIVE 2: Same as **Alternative 1**, but with a common cycle length of 90 seconds.

ALTERNATIVE 3: Existing intersection geometry, AM and PM Peak Hour signal timing optimized using Synchro and allowing intersections to be grouped into clusters, each of which is optimized separately. The result of this operation is that Anzio Road and Hartford Street become one cluster, while the remaining signalized intersections form another cluster.

ALTERNATIVE 4: Existing intersection geometry. Signal at Anzio Road excluded from the cycle-length / phasing optimization, set at "intersection optimal" (60 seconds); other intersections optimized.

The Union Avenue intersection was assumed to remain unsignalized for all these alternatives; consequently, this intersection, and the Concord / Howard Street intersection, were excluded from the optimizations.

Table 5 provides a summary of the overall network-wide travel time and delay results for these alternatives, compared with the existing uncoordinated signal operation. T**able 6** shows the intersection levels of service and queuing characteristics for the two

critical intersections at Anzio Road and Hartford Street under each of the alternative signal regimes. In **Table 6**, queues and approach Levels of Service are shown only for the critical approaches—the northbound through movement at each intersection, and any movements for which the 95th percentile queue is identified by Synchro as "exceeding available capacity".

The first conclusion is that all the alternatives investigated manifest improved operation system-wide, in terms of reduced travel times, and particularly reduced signal delays and queues, compared with existing uncoordinated signal operation.

The greatest improvement appears to result when signals are all set to a 70-second cycle in AM and PM Peak Hours. The 70-second cycle alternative yields major reductions in queues for northbound vehicles on Concord Street, particularly at the Anzio Road intersection. **Alternatives 1** and **3** essentially reduce to the same scenario, since the optimal cycle length for both intersection "clusters" of **Alternative 3** is selected to be 70 seconds. **Alternative 4**, under which Anzio Road is excluded from optimization, was included because of the current differences in cycle lengths between this intersection and the Hartford Street intersection. This alternative does not compare favorably with the other alternatives which do include Anzio Road in the optimization. Nor does **Alternative 2** (90-second cycle), which exhibits travel time reductions and queues similar to those of **Alternative 4**.

In none of the alternatives examined does signal coordination eliminate northbound queues or insure that such queues will not exceed existing roadway capacity. This is because volumes in this corridor are high, and the benefits associated with more efficient arterial bandwidths are incremental compared with the benefits associated with (for example) adding capacity through roadway widening or similar improvements. However, the degree of improvement associated with improved corridor signal efficiency will reduce the extent and duration of the worst vehicle queues, and in the short term can forestall the need for adding capacity.

5.2. Other Alternatives

In addition to signal timing manipulation, other potential improvements were examined, including:

- the proposal from the 1997 study for signalizing the Concord Street (Route 126) / Union Avenue intersection, in front of Memorial Building in Downtown Framingham.
- provision of two northbound lanes on Concord Street at the Anzio Road intersection.

Signalizing the Concord Street / Union Avenue intersection has been considered in the past. The purpose of this evaluation was to determine whether the inclusion of this location as a signalized intersection would produce different signal coordination results for the corridor as a whole; and to quantify the queuing implications of such a strategy in Downtown Framingham.

TABLE 5
Analysis of Existing Conditions
Without and With Coordination:
Summary of Overall Network Results

ALTERNATIVES	Overall Network Measures				
	Signal %-ile Delay[1]	Avg. Speed[2]	Total Travel Time[3]	Queue Penalty[4]	Perform-ance Index[5]
AM PEAK HOUR					
EXISTING SIGNAL TIMING	35	23	149	1549	95.3
1. 70-sec. Cycle	**30**	23	**144**	**872**	**69.9**
2. 90-sec. Cycle	33	23	147	1213	82.6
3. Zoned network,[6] ➔ 70-second cycle in both zones	**30**	23	**144**	**872**	**69.9**
4. Anzio optimized separately, not included in progression	33	23	146	1161	81.5
PM PEAK HOUR					
EXISTING SIGNAL TIMING	42	22	177	2185	122.7
1. 70-sec. Cycle	**35**	23	**170**	**1356**	**91.2**
2. 90-sec. Cycle	37	23	172	1760	104.6
3. Zoned network,[6] ➔ 70-80 second cycles	37	23	172	1560	100.2
4. Anzio optimized separately, not included in progression	41	23	176	1828	111.9

[1] Overall delay calculated using the Synchro Percentile method. Vehicles assumed to arrive randomly, with 20 percent of traffic in each of 5 arrival-rate bands; delay is then averaged out over all 5 arrival bands for each intersection, and all intersections are cumulated into a single total value.
[2] Link distance divided by travel time, including delay, averaged over all vehicles.
[3] Total travel time summed over all vehicles.
[4] Measures effects of queuing and blocking. Calculated by measuring percent of blocking time by number of vehicles affected. **Lower** values are preferable.
[5] Combination of delays, stops and queuing penalty. When optimizing, Synchro selects the cycle length with the **lowest** PI.
[6] Uses Synchro option which allows network to be sectioned, with individual sections then optimized. Different sections may have the same, or different, cycle lengths.

Bold type indicates best performance on an indicator.

TABLE 6
Analysis of Existing Conditions
Without and With Coordination:
Summary of Critical Intersection Results

ALTERNATIVES	Inters'n: Concord at:	NB Queue 50-%ile	NB Queue 95-%-ile	NB Queue ID	Other Queue 50-%ile	Other Queue 95-%ile	Inters'n LOS	Worst-Move LOS	Worst-Move Move
AM PEAK HOUR									
EXISTING SIGNAL TIMING	Anzio	563	795	SBL EBL	34 198	133 336	B (16.3)	D	EBL
	Hartford	176	371	_____	_____	_____	A (7.2)	C	WBL
1. 70-sec. Cycle	Anzio	282	628*	SBL EBL	13 120	40 253	B (14.5)	D	EBL
	Hartford	122	198	_____	_____	_____	A (4.6)	C	WBL
2. 90-sec. Cycle	Anzio	345	641*	SBL EBL	13 137	40 270	B (14.3)	D	EBL / SBL
	Hartford	163	369*	_____	_____	_____	A (7.0)	D	WBL
3. Zoned network#, ➔ 70-80 second cycles	Anzio	282	628*	SBL EBL	13 120	40 253*	B (14.5)	D	EBL
	Hartford	122	198	_____	_____	_____	A (4.6)	C	WBL
4. Anzio optimized separately, not in-cluded in progression	Anzio	345	641*	SBL EBL	13 120	40 253	B (16.3)	D	EBL
	Hartford	163	369*	_____	_____	_____	B (7.6)	C	WBL
PM PEAK HOUR									
EXISTING SIGNAL TIMING	Anzio	583	943*	SBL EBL	98 113	212* 219*	B (17.2)	D	EBL / SBL
	Hartford	223	545*	_____	_____	_____	B (10.6)	C	WBL
1. 70-sec. Cycle	Anzio	79	600*	SBL EBL	46 72	137* 170*	B (12.3)	D	EBL
	Hartford	163	503*	_____	_____	_____	A	C	WBL

Table 6 (cont'd)

2. 90-sec. Cycle	Anzio	604	815*	SBL EBL	76 95	196* 199*	B (15.7)	D	EBL / SBL
	Hartford	246	388	_____	_____	_____	A	D	WBL
3. Zoned network#, ➔ 70-80 second cycles	Anzio	424	759*	SBL EBL	60 83	154* 180*	B (13.4)	D	EBL
	Hartford	234	418	_____	_____	_____	A	C	WBL
4. Anzio optimized separately, not in-cluded in progression	Anzio	318	615*	SBL EBL	31 61	121* 157*	B (16.1)	D	EBL
	Hartford	219	502*	SBT	170	401*	B	C	WBL

* indicates 95th percentile queue exceeds capacity; value shown represents queue after 3 minutes.

\# uses Synchro option which allows network to be sectioned, with individual sections then optimized. Different sections may have the same, or different, cycle lengths.

Provision of 2 northbound lanes on Concord Street at Anzio Road was also evaluated because northbound queues extending from this location manifestly interfere with operations at the Concord Street / Hartford Street intersection upstream. The pavement in this section of Concord Street currently accommodates one travel lane in each direction separated by a median lane serving left-turning traffic in both directions. The analysis was intended to demonstrate whether substantial queue reduction benefits might be obtained, on Concord Street between Hartford and Anzio, if the existing three-lane cross-section were widened to provide for 2 northbound lanes and 1 southbound lane, plus the median left-turn lane.[7]

These alternatives were examined using the same methodologies used to evaluate existing conditions and coordinated operation of existing signals:

ALTERNATIVE A: signal installation at Concord Street / Union Avenue, assuming one northbound through, one northbound left-turn lane.

ALTERNATIVE B: same as A, but with 2 northbound through lanes, 1 left-turn lane, on Concord Street approaching Union Avenue.

ALTERNATIVE C: signal installation at Concord Street / Union Avenue as in B, *PLUS* widening to provide a second northbound through lane on Concord Street between Hartford Street and Anzio Road.

The associated cycle lengths and observed queues / system delays are summarized in **Table 7**. Intersection Levels of Service, and queue lengths for critical approaches at the three principal intersections are shown in **Table 8** for each alternative. In **Table 7**, it is worth noting that both total travel times and signal delays are longer than for the alternatives which include a signal at Concord Street / Union Avenue than they are for **Alternatives 1-4**, discussed above. This is *both* because the additional signal imposes added delays *and* because any delays associated with operations at unsignalized intersections are essentially ignored by Synchro, and are not included in the overall estimates under the earlier alternatives.

[7] Alternatively, the existing cross-section width of Concord Street might be retained, but altered to provide 2 northbound and 1 southbound lane, eliminating the median left-turn lane. This option does not yield improved operations compared with the other alternatives, because of the increase in southbound left-turn delays.

Table 7
Analysis of Other Alternatives
With Signal Coordination:
Summary of Overall Network Results

ALTERNATIVES	Overall Network Measures				
	Signal %-ile Delay[1]	Avg. Speed[2]	Total Travel Time[3]	Queue Penalty[4]	Perform-ance Index[5]
AM PEAK HOUR					
A. Concord/Union signalized	35	23	149	1022	81.1
B. Concord/Union signalized, 2 thru NB lanes at Union	34	23	148	990	78.5
C. Same as Alt B, with 2 thru NB lanes at Anzio	**32**	23	**146**	**928**	**73.3**
PM PEAK HOUR					
A. Concord/Union signalized	50	22	184	1544	114.0
B. Concord/Union signalized, 2 thru NB lanes at Union	48	22	182	1668	114.8
C. Same as Alt B, with 2 thru NB lanes at Anzio	**46**	22	**180**	**1418**	**104.7**

[1] Overall delay calculated using the Synchro Percentile method. Vehicles assumed to arrive randomly, with 20 percent of traffic in each of 5 arrival-rate bands; delay is then averaged out over all 5 arrival bands for each intersection, and all intersections are cumulated into a single total value.
[2] Link distance divided by travel time, including delay, averaged over all vehicles.
[3] Total travel time summed over all vehicles.
[4] Measures effects of queuing and blocking. Calculated by measuring percent of blocking time by number of vehicles affected. **Lower** values are preferable.
[5] Combination of delays, stops and queuing penalty. When optimizing, Synchro selects the cycle length with the **lowest** PI.

Bold type indicates best performance on an indicator.

TABLE 8
Analysis of Other Alternatives
With Signal Coordination:
Summary of Critical Intersection Results

ALTERNATIVES	Inters'n: Concord at:	NB Queue 50-%ile	NB Queue 95-%-ile	Other Queue ID	Other Queue 50-%ile	Other Queue 95-%ile	Inters'n LOS	Worst-Move LOS	
								LOS	Move
AM PEAK HOUR									
A. Concord / Union signalized	Anzio	344	628*	SBL EBL	13 120	40* 253*	B (14.6)	D	EBL
	Hartford	169	352	_____	_____	_____	A (5.4)	C	WBL
	Union	45	62	NBL	248	380*	A (8.2)	D	EBL
B. Concord / Union signalized, 2 thru NB lanes at Union	Anzio	344	628*	SBL EBL	13 120	40* 253*	B (14.5)	D	EBL
	Hartford	169	352	_____	_____	_____	A (5.6)	C	WBL
	Union	6	7	NBL SBT	246 32	377* 75*	A (7.0)	D	EBL
C. Same as Alt B, with 2 thru NB lanes at Anzio	Anzio	75	101	EBL	113	223*	B (10.5)	C	EBL
	Hartford	169	352	_____	_____	_____	A (5.3)	C	WBL
	Union	6	7	NBL	248	380*	A (7.5)	D	EBL
PM PEAK HOUR									
A. Concord / Union signalized	Anzio	79	660*	SBL EBL	46 72	137* 170*	B (12.3)	D	EBL
	Hartford	225	504*	_____	_____	_____	A (8.0)	C	WBL
	Union	72	94	NBL SBT	402 292	625* 457*	B (18.1)	D	EBL
B. Concord / Union signalized, 2 thru NB lanes at Union	Anzio	79	660*	SBL EBL	46 72	137* 170*	B (12.3)	D	EBL
	Hartford	225	504*	_____	_____	_____	A (8.0)	C	WBL
	Union	8	11	NBL SBT	398 278	601* 470*	B (15.7)	D	EBL

Table 8 (cont'd)

C. Same as Alt B, with 2 thru NB lanes at Anzio	Anzio	45	87	EBL	69	150*	A (7.5)	C	EBL
	Hartford	225	504*	_____	_____	_____	A (7.8)	C	WBL
	Union	8	11	NBL SBT	392 278	619* 554*	B (17.7)	D	EBL

* indicates 95th percentile queue exceeds capacity; value shown represents queue after 3 minutes

(a) **Alternatives A** and **B**

Under **Alternatives A** and **B**, the Concord Street / Union Avenue intersection is assumed to be signalized. Signalizing a complex downtown intersection may result in more orderly assignment of right-of-way among conflicting traffic flows. It is also likely to increase queue lengths and delays to stopped traffic. The reason for analyzing this alternative is to determine how well a signalized Concord Street / Union intersection can be incorporated into the Route 126 corridor with optimized signal progression, and to determine the queuing impacts, particularly on the northbound Concord Street approach.

For **Alternative A**, the 2-lane northbound Concord Street approach was assumed to become 1 northbound through lane, and 1 left-turn lane at the Union Avenue intersection. For **Alternative B**, 2 northbound through lanes plus a short left-turn bay were assumed, although it may not be possible to provide an additional through *or* left-turn lane without severely impacting on-street parking and / or the sidewalk width here and in the downstream receiving lanes.

For both alternatives, the critical movements subject to delays and queuing are the northbound left turn, from Concord Street into Union Avenue, and the southbound through movement on Concord Street. Both these movements would generate long queues in the PM Peak Hour under any signalized alternative. Other alternatives were also examined, including double-left turn lanes on the northbound approach, and placing the master controller at the Concord Street / Union Avenue intersection instead of at Hartford Street. None of these other alternatives represented an improvement over the alternatives presented, in terms of system-wide performance measures, although the double-left turn lane on Concord Street northbound does reduce queue lengths on this approach.

Left-turn or U-turn traffic currently represents a substantial portion of demand at this location. In the morning, at least, some of this demand is associated with traffic bound for the railroad station. Currently, vehicles coming from south of Route 135 cannot turn left from Route 126 into the railroad station—they need to make a U-turn at Union Avenue in order to access the station. The number of these vehicles may be reduced when the Downtown Framingham Railroad Station / stop is moved to the east side of the tracks; in the future, these vehicles will make *right* turns, rather than *indirect left* turns, into the station.

Southbound queues and delays in the afternoon are not reduced by these alternatives, and may even be made somewhat worse as a result of signalization. The options for improving the operation of this movement are limited, particularly when the critical movement in the intersection is the opposing northbound left turn. Some improvement could be made if 2-5 curbside parking spaces on the west side of Concord Street could be removed, to be replaced with a right-turn lane. But opposition to parking space removal is likely to be high, and the resulting benefit may not be deemed worth the cost by Town officials.

The MBTA's Worcester Extension project includes, in addition to the railroad station relocation mentioned above, the redesign of the grade crossing and traffic signals at Concord Street (Route 126) and Route 135. It would be desirable for the redesign to proceed under the assumption that the Concord Street / Union Avenue intersection *will* at some point be signalized, and that the signals between Route 135 and Union Avenue will all be interconnected with optimized progression and pre-emption as necessary.

(b) **Alternative C**

The best results overall, in terms of minimizing overall travel time through the corridor without resulting in significant LOS penalties or unacceptably long queues at any intersection, are obtained under **Alternative C.** This alternative includes restriping or minor widening of Route 126 above Hartford Street, in addition to the signalization of Concord Street / Union Avenue. It appears that the use of a 2-lane northbound approach (1 through lane, 1 through / right-turn lane) on Concord Street at Anzio Road would reduce northbound delays in this segment of Concord Street, with beneficial effects spilling back into the Concord Street / Hartford Street intersection.

If such widening were seriously contemplated at any stage, it should probably be carried through the length of Route 126 at least to Route 9. At Route 9, the right-most lane could become an exclusive lane to the Route 9 EB on ramp; alternatively, two lanes could be carried through to the bridge over Route 9, which is already striped for 2 lanes in the northbound direction.

There are potential difficulties with the idea of allowing 2 northbound lanes in this section, however. First, barring any widening or land-taking, such an alternative would replace the continuous left-turn lane which currently exists in the median of Concord Street with a uni-directional through lane. This would represent a disadvantage from an access point of view for intersecting side-streets and commercial properties abutting Concord Street here. Alternatively, the existing sidewalks could be cut back and minor takings made from abutting properties if it was desired to retain the continuous median left-turn lane.[8] This strategy similarly may not be popular with abutters.

Finally, although pedestrian volumes crossing Concord Street in this area are not high, there is a moderate amount of pedestrian traffic. In particular, one or several schools appear to be located within the complex of buildings located on the west side of Concord Street in this area; and a school crossing guard is on duty at Normandy Road during the morning arrival period to stop traffic for children crossing the street. While this does not happen more than every few cycles during part of the morning peak, it does limit the potential effectiveness of signal progression efforts in this area; and widening the paved street width to four lanes would increase walking distance for pedestrians.

[8] MassHighway's *Design Manual* allows two-way left-turn lanes for roadways with no more than two through lanes in each direction, provided these also meet other criteria; see Commonwealth of Massachusetts, Massachusetts Highway Department, *Highway Design Manual*, Metric Edition (1997), Section 7.3.3.

6. Conclusions and Recommendations

The principal conclusion drawn from the analysis is that the potential benefits to be gained from implementing traffic signal progression in the Route 126 corridor are real, but limited. Such progression would result in measurable reductions in queue lengths and corridor travel times for most travelers; although they would not eliminate queues and delays outright, because of the high traffic demand in the corridor, the uneven spacing of signals, and the large number of intermediate unsignalized intersections.

a. We recommend that signals be coordinated as an element of any future corridor-wide improvement project.

b. Signal progression should be based on short cycle lengths corridor-wide. Our analysis showed the best results for the existing geometry and signal locations with an overall cycle length of 70 seconds for AM and PM peak hours, with Concord / Hartford Street as the master intersection from which offsets are referenced, i.e., **Alternative 1**. Other cycle lengths and configurations, including longer overall cycle lengths, varying cycle lengths for adjacent intersection clusters, and the options which include a signalized Concord Street / Union Avenue, are less successful in terms of system-wide measures of effectiveness, although they may produce better service levels and / or shorter queues on selected approaches at one or more intersections.

c. We recommend that a detailed design feasibility study be undertaken by an experienced traffic signal designer before a decision is made whether to signalize the intersection of Concord Street and Union Avenue in Downtown Framingham. Signalizing this intersection would improve safety, by imposing an orderly assignment of right-of-way; but it is also likely to increase queues and delays.

Signalization at this intersection would not be a simple undertaking; it would require interconnecting with the signals at Howard Street and the railroad tracks in Downtown Framingham. The critical movement for a signalized intersection at this location will be the northbound left turn from Concord Street to Union Avenue, in front of Memorial Hall. Care should be taken to avoid spillback of this movement into Howard Street and the tracks beyond.

If possible, redesign of the signal system at the intersection of Concord Street with Waverley Street at the railroad tracks, currently ongoing, should be expanded to include consideration of a future signal at the Concord Street / Union Avenue intersection.

d. Finally, we believe it is worth discussing options for improving Route 126 north of Hartford Street with Town of Framingham officials, to ascertain whether there is likely to be any support for modifying the existing lane configuration in this area. Widening the section of Concord Street between Hartford Street and Route 9 to provide two northbound lanes would provide substantially better operation in this section of Route 126 than simply modifying existing signal timing, and would reduce queues and delays for northbound traffic. This option may be worth pursuing only if it can be made acceptable to abutters and other local representatives.

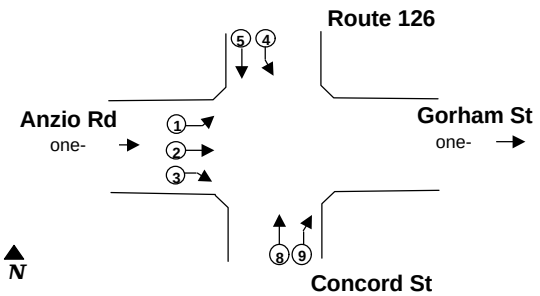
APPENDIX A: Traffic Data

1. Traffic Counts
2. Intersection Geometry / Signal Timing
3. Measured Intersection Queues

Street:	Anzio Rd			Concord RD				Concord Rd					
Direction:	EB			SB				NB					
Movement	L	S	R	L	S	R	L	S	R	L	SB	R	Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15	25	3	0	7	120			195	0				350
7:15-7:30	52	0	2	18	233			280	0				585
7:30-7:45	44	7	3	21	241			259	3				578
7:45-8:00	59	3	6	24	228			234	0				554
8:00-8:15	72	6	2	33	216			234	1				564
8:15-8:30	60	6	7	20	208			244	3				548
8:30-8:45	71	6	10	33	240			254	5				619
8:45-9:00	56	1	9	20	211			228	2				527
9:00-9:15													0
9:15-9:30													0
Col.Total	439	32	39	176	1697	0	0	1928	14	0	0	0	4325
AM PEAK 7:45-8:45 HOUR	262	21	25	110	892	0	0	966	9	0 PHF =	0 0.92	0	2285

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15	57	9	10	33	245			229	1				584
4:15-4:30	40	5	5	39	265			236	0				590
4:30-4:45	51	22	11	39	242			231	11				607
4:45-5:00	48	5	1	41	258			258	0				611
5:00-5:15	41	6	1	63	261			283	0				655
5:15-5:30	36	4	6	45	278			272	2				643
5:30-5:45	42	5	0	58	268			274	2				649
5:45-6:00	30	6	5	35	261			259	2				598
6:00-6:15													0
6:15-6:30													0
Col.Total	345	62	39	353	2078	0	0	2042	18	0	0	0	4937
PM PEAK 4:45-5:45 HOUR	167	20	8	207	1065	0	0	1087	4	0 PHF =	0 0.98	0	2558

SKETCH



Date: September 14/30, 1999
Day: Tuesday/Thursday
Weather: Rain/Dry
By: SWG
City: Framingham, MA
Location: Rt 126 (Concord St) at Anzio Rd/Gorham St

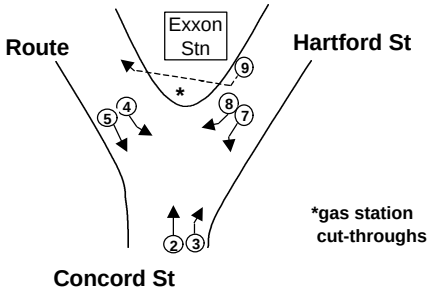
TRAFFIC COUNT | Figure

/metrowest/rt126/analysis/counts/fr1.xls

Street:		Concord		Concord St			Hartford St						
Direction:			NB	SB				WB					
Movement:		S	R	L	S		L	R	RR*	L	SB	R	Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15		206	41	14	137		36	38	1				473
7:15-7:30		179	28	15	152		24	38	1				437
7:30-7:45		171	40	6	177		17	47	2				460
7:45-8:00		133	48	21	193		36	61	0				492
8:00-8:15		135	33	26	155		30	51	0				430
8:15-8:30		154	30	26	176		35	46	0				467
8:30-8:45		149	28	18	167		41	43	0				446
8:45-9:00		173	28	15	193		31	65	0				505
9:00-9:15													0
9:15-9:30													0
Col.Total	0	1300	276	141	1350	0	250	389	4	0	0	0	3710
AM PEAK 7:00-8:00	0	689	157	56	659	0	113	184	4	0	0	0	1862
HOUR									PHF =	0.92			

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15		186	36	12	220		61	32					547
4:15-4:30		197	20	25	249		33	41					565
4:30-4:45		203	27	20	241		33	42					566
4:45-5:00		209	43	20	226		30	44					572
5:00-5:15		209	30	25	234		44	55					597
5:15-5:30		201	29	32	229		55	45					591
5:30-5:45		198	36	20	221		46	43					564
5:45-6:00		191	23	26	221		53	53					567
6:00-6:15													0
6:15-6:30													0
Col.Total	0	1594	244	180	1841	0	355	355	0	0	0	0	4569
PM PEAK 4:30-5:30	0	822	129	97	930	0	162	186	0	0	0	0	2326
HOUR									PHF =	0.97			

SKETCH



Date: September 16/30, 1999
Day: Thursday
Weather: Rain/Dry
By: TEngel
City: Framingham, MA
Location: Rt 126 (Concord St) at Hartford St

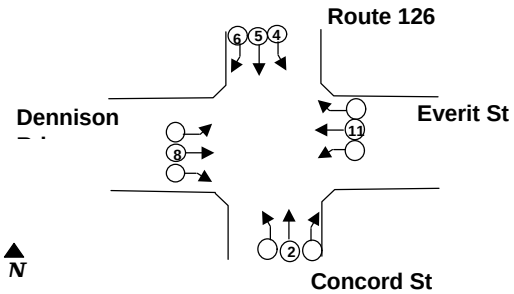
TRAFFIC COUNT | Figure

/metrowest/rt126/analysis/counts/fr2.xls

Street:	Concord Rd			Concord Rd			Dennison Rd			Everit St			
Direction:	NB			SB			EB			WB			
Movement:	S			L	S	R	L			R			Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15		153		1	105	1		3			3		266
7:15-7:30		160		1	132	1		0			3		297
7:30-7:45		216		4	193	2		4			2		421
7:45-8:00		126		3	145	1		3			5		283
8:00-8:15		117		4	142	1		3			6		273
8:15-8:30		145		2	153	5		5			3		313
8:30-8:45		137		7	176	6		2			1		329
8:45-9:00		165		1	160	2		1			3		332
9:00-9:15													0
9:15-9:30													0
Col.Total	0	1219	0	23	1206	19	0	21	0	0	26	0	2514
AM PEAK													
7:30-8:30	0	604	0	13	633	9	0	15	0	0	16	0	1290
HOUR									PHF =		0.77		

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00		127		4	153	2		0			2		288
4:00-4:15		182		6	201	3		5			4		401
4:15-4:30		171		0	203	4		4			4		386
4:30-4:45		197		0	215	5		5			14		436
4:45-5:00		191		4	174	3		2			1		375
5:00-5:15		202		2	207	4		3			7		425
5:15-5:30		177		5	193	1		11			5		392
5:30-5:45		178		7	202	2		2			5		396
5:45-6:00		172		2	196	4		5			5		384
6:00-6:15													0
6:15-6:30													0
Col.Total	0	1597	0	30	1744	28	0	37	0	0	47	0	3483
PM PEAK													
4:30-5:30	0	767	0	11	789	13	0	21	0	0	27	0	1628
HOUR									PHF =		0.93		

SKETCH



Date: September 30, 1999
Day: Thursday
Weather: Rain
By: MPM
City: Framingham, MA
Location: Rt 126 (Concord St) at Everit/Dennison Road (partial count only)

TRAFFIC COUNT | Figure

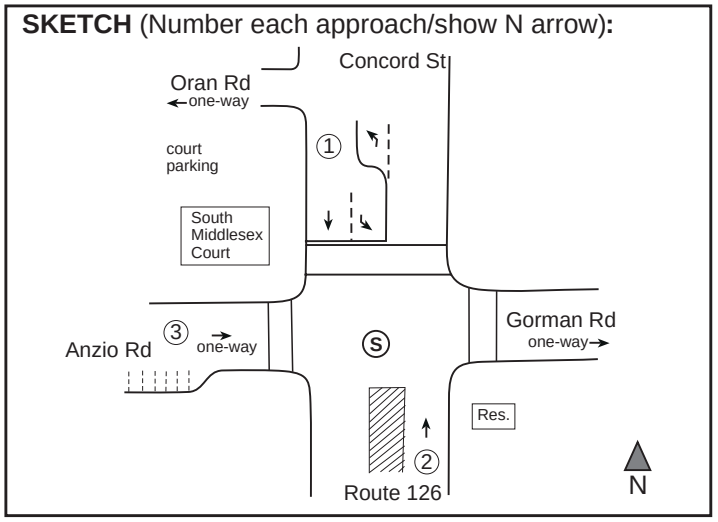
/metrowest/rt126/analysis/counts/fr3.xls

CTPS INTERSECTION DATA FORM

DATE: October 6,1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 126 Signal Timing

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Framingham, MA

2 Intersection: Route 126 (Concord St) at

At: Anzio/Gorman Rd

3 Intersection #: 1

B. Traffic Control Devices:

Approach #:

1. Signal
2. Signal
3. Signal--actuated (1 loop in pavement)
4.

Signals: P = pretimed
A = actuated

(over for signal timing)

C. Speed Limits:

Approach #:

1.
2.
3.
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

APPROACH #

	1	2	3	4
1 Sidewalks	B	B	B	B
2 Curbing	B	B	B	B
3 Parking?	N	N	Y#	L^
4 Parking Restricted?	--	--	Y#	Y^
5 No. of Lanes	2	1	1**	
6 Exclusive Lanes?	LT	--	**	
7 Lane Widths	12-11	15	16+	
8 Bus Stops?	N	N	N	
9 Grade	0%	0%	0%	
10 Crosswalk? (draw)	Y	N	Y	
11 Classification*				
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

^ resident pkg only
**drives as 1 LT, 1 TH/RT
HP & police pkg on left, plus angle parking on right

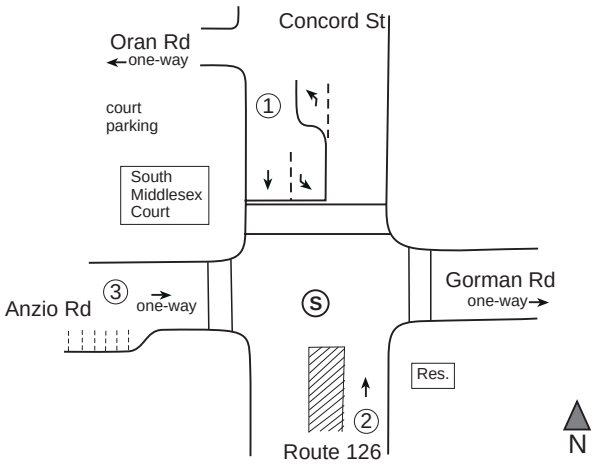
F. Comments/Observations

Signal has pedestrian buttons at crosswalk ends. Advance green for SB Concord St (3-ball signals--no turn arrows)

Anzio St. is exit route for Courthouse parking. Middle "lane" used for left turns in entire section of Rt 126.

Concord NB queues back almost to Hartford. School crossing guard at Normandy Rd also stops traffic.

/metrowest/rt126/analysis/geometry/i1.cdr



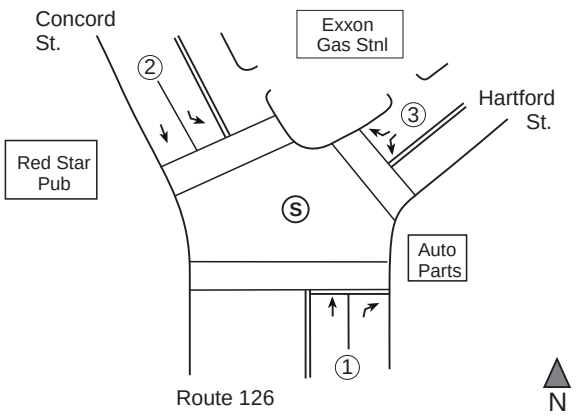
	A	B	C	
AM:	G: 30 Y: 3	G: 8 Y: 0	G: 70 Y: 3	114 sec.
PM:	G: 22 Y: 3	G: 10 Y: 0	G: 69 Y: 3	107 sec.

CTPS INTERSECTION DATA FORM

DATE: September 22,1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 126 Signal Timing

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Framingham, MA

2 Intersection: Route 126 (Concord Street) at

At: Hartford Street

3 Intersection #: 2

B. Traffic Control Devices:

Approach #:

1. Signal
2. Signal--Actuated LT
3. Signal--Actuated?
4.

Signals: P = pretimed
A = actuated
(over for signal timing)

C. Speed Limits:

Approach #:

1. 30 mph
2. 25 mph
3. (25 mph?)
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	B	B	B	
2 Curbing	B	B	B	
3 Parking?	N	N	L	
4 Parking Restricted?	--	--	N	
5 No. of Lanes	2	2	1	
6 Exclusive Lanes?	1R	1L	(**)	
7 Lane Widths	12-10	12-10	15?	
8 Bus Stops?	N	N	N	
9 Grade	0%	0%	0%	
10 Crosswalk? (draw)	Y	Y	Y	
11 Classification*				
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

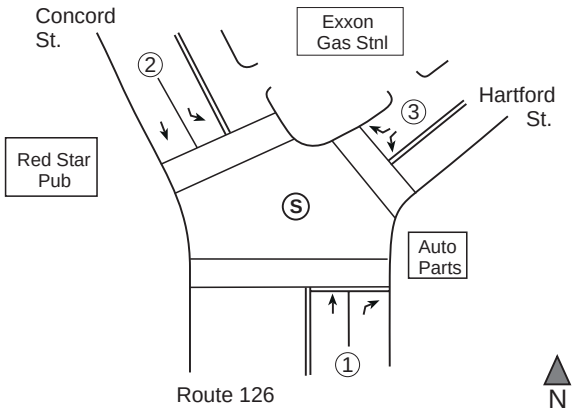
**not striped, but room for separate rights & lefts

F. Comments/Observations

Signal has pedestrian buttons at crosswalk ends.

All signal heads are 3-ball with W/DW; no protected turns or advance greens.

/metrowest/rt126/analysis/geometry/i2.cdr



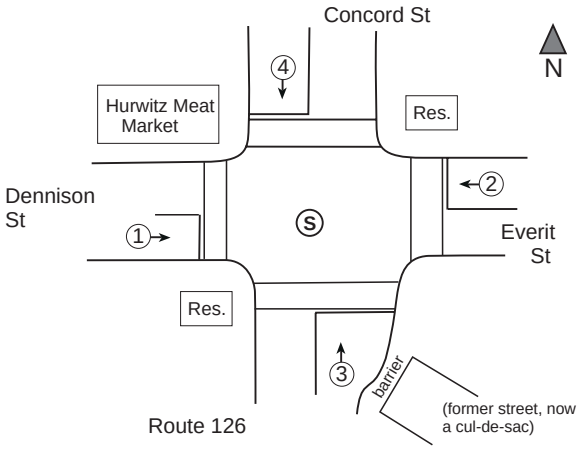
	A	B	C	
AM:	G: 8 Y: 0	G: 40 Y: 3	G: 22 Y: 3	76 sec.
PM:	G: 8 Y: 0	G: 40 Y: 3	G: 24 Y: 2	77 sec.

CTPS INTERSECTION DATA FORM

DATE: September 22,1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 126 Signal Timing

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Framingham, MA

2 Intersection: Route 126 (Concord St) at

At: Dennison St/Everit St

3 Intersection #: 3

B. Traffic Control Devices:

Approach #:

1. Signal--Actuated
2. Signal--Actuated
3. Signal--Actuated?
4. Signal--Actuated?

Signals: P = pretimed A = actuated (over for signal timing)

C. Speed Limits:

Approach #:

1.
2.
3. 25 mph
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	B	B	B	B
2 Curbing	B	B	B	B
3 Parking?	B	L	N	N
4 Parking Restricted?	--	--	--	--
5 No. of Lanes	1	1	(1)**	1
6 Exclusive Lanes?	--	--	--	--
7 Lane Widths	20^	12	25?	15?
8 Bus Stops?	N	N	N	N
9 Grade	0%	0%	0%	0%
10 Crosswalk? (draw)	Y	Y	Y	Y
11 Classification*				
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

** 2 lanes wide at inter'n--striped for 1

^includes parking lane--not heavily parked

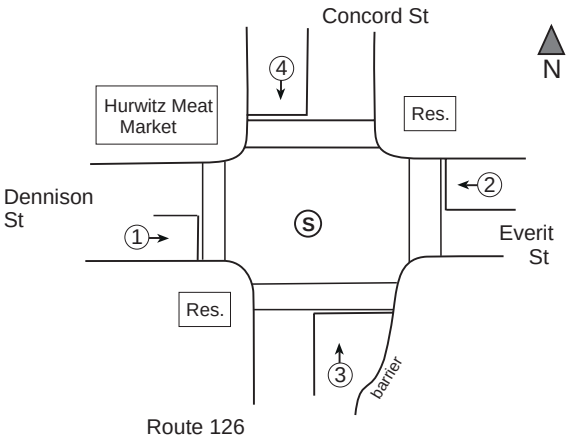
F. Comments/Observations

Signal has pedestrian buttons at crosswalk ends.

All signal heads are 3-ball with W/DW; no protected turns or advance greens.

(note where pre-existing street turned into cul-de-sac S of intersection).

/metrowest/rt126/analysis/geometry/i3.cdr



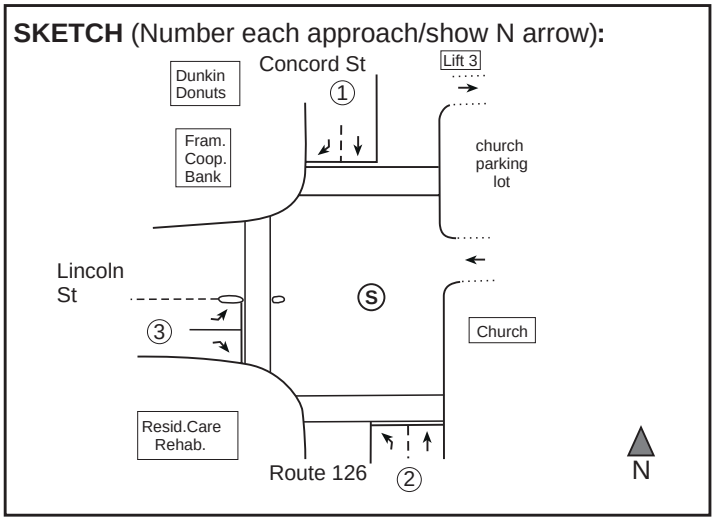
	A		B		
AM:	G: 13	Y: 3	G: 45	Y: 3	64 sec.
PM:	G: 11	Y: 3	G: 46	Y: 3	63 sec.

CTPS INTERSECTION DATA FORM

DATE: September 28,1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 126 Signal Timing

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Framingham, MA

2 Intersection: Route 126 (Concord St) at

At: Lincoln St/Church driveway

3 Intersection #: 4

B. Traffic Control Devices:

Approach #:

1. Signal
2. Signal
3. Signal
4.

Signals: P = pretimed
A = actuated

(over for signal timing)

C. Speed Limits:

Approach #:

1.
2.
3. 30 mph
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	B	B	B	
2 Curbing	B	B	B	
3 Parking?	N	R	N	
4 Parking Restricted?	--	Y^	--	
5 No. of Lanes	2	2	2	
6 Exclusive Lanes?	RT	LT	LR	
7 Lane Widths	11-12	11-12	11-12	
8 Bus Stops?	N	Y**	N	
9 Grade	0%	0%	0%	
10 Crosswalk? (draw)	Y	Y	Y	
11 Classification*				
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

^ no pkg 8-10am, 4-6pm
**north of inters'n

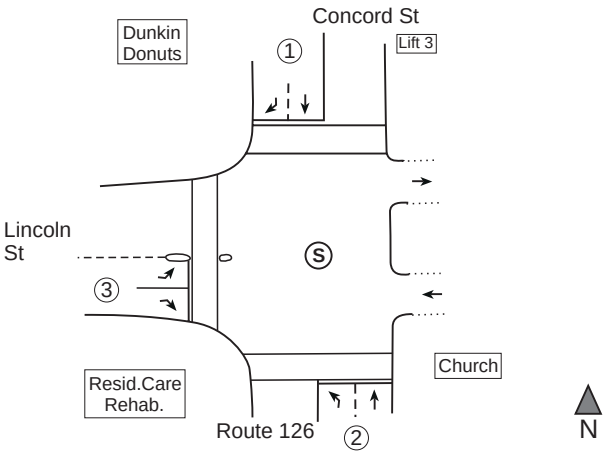
F. Comments/Observations

Signal has pedestrian buttons at crosswalk ends.

Right-turn arrow for Concord SB right turn--active during Lincoln St phase.

Directional signs for long-term parking, Hospital, Library.

/metrowest/rt126/analysis/geometry/i4.cdr



	A	B	
AM:	G: 26 Y: 4	G: 40 Y: 2	72 sec.
PM:	G: 26 Y: 4	G: 40 Y: 2	72 sec.

INTERSECTION QUEUES

PROJECT: MetroWest Subregional Study
LOCATION: Route 126 (Concord Ave) at Hartford Street
Framingham

DATE: Sept. 21 and Oct. 8, 1999
DAY: Wednesday/Thursday
BY: MPM

OBSERVED QUEUE LENGTHS PER CYCLE BY APPROACH

AM 7:15-8:00

	Concord St SB			Concord St NB			Hartford St WB						INT. AVERAGE	
	Left	Thru/Gen	Right	Left?	Thru/Gen	Right?	Left?	Thru/Gen	Right?	Left?	Thru/Gen	Right?	TOTAL	CRITICAL
1	1	13			32	a	1		4 b					
2	1	6			27		2		4 b					
3	0	0			32	a	3		1 b					
4	0	3			32	a	1		2 b					
5	0	9			32	a	1		3 b					
6	0	3			32	a	4		3 b					
7	0	4			32	a	0		3 b					
8	1	5			17	c	2		2 b					
9	2	4			22		2		3 b					
10	1	5			25		1		0 b					
11														
12														
13														
MAX	2	13	0	0	32	0	4	0	0	0	0	0		
AVG	0.6	5.2	0.0	0.0	28.3	0.0	1.7	0.0	2.5	0.0	0.0	0.0	7.7	28.3

PM 5:00-5:45

	Left?	Thru/Gen	Right?	Left?	Thru/Gen	Right?	Left	Thru/Gen	Right?	Left?	Thru/Gen	Right	INT. AVERAGE TOTAL	CRITICAL
1	0	20			19		3		2					
2	1	11			32		1		1					
3	4	21			30		6		3					
4	0	24			32	a	1		3					
5	0	14			32	a	1		4					
6	1	18			32	a	0		5					
7	6	9			32	a	2		0					
8	4	17			32	a	3		1 d					
9	5	17			32	a	2		1					
10	1	3			32	a	4		2 d					
11	1	13			32	a								
12					32	a								
13					32	a								
MAX	6	24	0	0	32	0	6	0	5	0	0	0		
AVG	2.1	15.2	0.0	0.0	30.8	0.0	2.3	0.0	2.2	0.0	0.0	0.0	11.6	30.8

/metrowest/rt126/analysis/queues/Hartford126.xls

a: "32" equals 30+ vehicles queued--end too far back to see.
b: Excludes right-turns-on-red, which are a large proportion of movements.
c: School crossing guard at Prindiville Avenue stopped traffic for student.
d: Blocked by northbound flow across intersection.

NOTES: Northbound vehicles routinely blocked by queues extending back from downstream intersection (Anzio).

INTERSECTION QUEUES

PROJECT: MetroWest Subregional Study
LOCATION: Route 126 (Concord Ave) at Howard St
Framingham

DATE: 02-Dec-99
DAY: Thursday
BY: MPM

OBSERVED QUEUE LENGTHS PER CYCLE BY APPROACH

AM 8:00-8:40	Concord St NB				Concord St SB				Howard St WB				Howard St EB				INT. AVERAGE	
	Left	Thru	Thru/Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right		TOTAL	CRITICAL
1		8	11		1	4				5			3	0		h		
2		12	12		0	4				1			5	2		h		
3		9	9		1	3				1			2	3		h		
4		6	14	c	2	12				0			4	0		h		
5		5	10	a	0	3		a		6			3	0		h		
6		6	6	a	2	8				9		a	3	0		a		
7		10	7		2	3				7			5	2		h		
8		9	10		0	4				0			2	0		h		
9		6	8	c	0	11		c		7			3	1		h		
10		10	6	a	8	15				5			2	0		h		
11		10	10	a	2	5		d		7			3	0		h		
12																		
13																		
MAX	0	12	14		8	15	0		0	9	0		5	3	0			
AVG	0.0	8.3	9.4		1.6	6.5	0.0		0.0	4.4	0.0		3.2	0.7	0.0		4.9	6.3

PM 4:33-5:15, plus 5:40	Concord St NB				Concord St SB				Howard St WB				Howard St EB				INT. AVERAGE	
	Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right		TOTAL	CRITICAL
1		5	3	g		15		e		6		h	4	5		h		
2		3	6	g		19		e		4		h	0	3		h		
3		2	4	g		17		e		8		h	10	5		h		
4		4	13	f		14		e		2		h	2	0		h		
5		5	8	g		10		e		4		h	2	4		h		
6		5	5	g		13		e		12		h	3	5		h		
7		7	14	f		21		e		0		h	6	1		h		
8		4	7	g		20		e		4		h	3	3		h		
9		4	6	g		19		e		3		h	2	7		h		
10		5	12	f						8		h	5	2		h		
11													12	13		h		
12													7	8		h		
13																		
MAX	0	7	14		0	21	0		0	12	0		12	13	0			
AVG	0.0	4.4	7.8		0.0	16.4	0.0		0.0	5.1	0.0		4.7	4.7	0.0		6.9	10.8

/metrowest/rt126/analysis/queues/Howard-126.xls

a: Followed by grade crossing event, during which NB queue clears, then Howard given green.
Grade crossing duration between 80 seconds and 2.5 minutes (no g/c events observed in PM).
b: Spillover into Route 135.
c: Long trucks cause spillovers or platoons.
d: Tailback was 18+ vehicles at end of 2.5-minute grade crossing event.
e: Longest lane (of 2) only; after 15-16 vehicles, queue splits at Union.
f: Queue spills into Route 135 intersection because of left turns from Rt 135 EB.
g: Queue held back at Route 135 signal--doesn't really represent approach volume (note also: constrained by backups from Union later in PM peak)
h: Many RTOR esp. during pedestrian phase (despite sign prohibition on WB approach)
note also: Howard right turns blocked by RR track queue extending across Howard.

NOTES: Northbound vehicles blocked by queues extending back from downstream intersection (Anzio)

INTERSECTION QUEUES

PROJECT: MetroWest Subregional Study
LOCATION: Route 126 (Concord Ave) at Lincoln Street
Framingham

DATE: 06-Oct-99
DAY: Wednesday
BY: MPM

OBSERVED QUEUE LENGTHS PER CYCLE BY APPROACH

AM 7:15-8:00

	Concord St SB				Concord St NB				Lincoln St EB							INT. AVERAGE	
	Left	Thru/Gen	Right		Left?	Thru/Gen	Right?		Left?	Thru/Gen	Right?		Left?	Thru/Gen	Right?	TOTAL	CRITICAL
1		0			0	5			2		3	a					
2		4			0	1			2		0	a					
3		3			0	1			2		0	a					
4		2			0	1			4		0	a					
5		0			0	9			3		0	a					
6		0			0	3			6		0	a					
7		2			0	5			3		0	a					
8		5			1	4			4		0	a					
9		5			0	3			1		0	a					
10		1			0	5			8		0	a					
11									5		0	a					
12																	
13																	
MAX	0	5	0		1	9	0		8	0	0		0	0	0		
AVG	0.0	2.2	0.0		0.1	3.7	0.0		3.6	0.0	0.3		0.0	0.0	0.0	2.0	3.7

PM 4:10-4:30

	Concord St SB				Concord St NB				Lincoln St EB							INT. AVERAGE	
	Left?	Thru/Gen	Right?		Left?	Thru/Gen	Right?		Left	Thru/Gen	Right?		Left?	Thru/Gen	Right	TOTAL	CRITICAL
1		2			0	6			3		1						
2		5			1	3			4		1						
3		4			1	2			2		2						
4		0			2	2			5		2						
5		5		b	1	8			9		1						
6		3		b	2	3			4		0						
7		3		b	2	1			2		0						
8		4		b	1	8			7		0						
9		10		b	2	6			2		0						
10		9		b	2	2			5		0						
11		12		b					5		1						
12		8							2		5	b					
13																	
MAX	0	12	0		2	8	0		9	0	0		0	0	0		
AVG	0.0	5.4	0.0		1.4	4.1	0.0		4.2	0.0	0.0		0.0	0.0	0.0	3.3	4.8

/metrowest/rt126/analysis/queues/Hartford126.xls

a: Actuated left-turn, so no zeros?
b: Several times, SB backup from downtown extended to/beyond Lincoln Street

NOTES: Northbound vehicles blocked by queues extending back from downstream intersection (Anzio)

INTERSECTION QUEUES

PROJECT: MetroWest Subregional Study
LOCATION: Route 126 (Concord Ave) at Anzio Road
Framingham

DATE: 06-Oct-99
DAY: Wednesday
BY: MPM

OBSERVED QUEUE LENGTHS PER CYCLE BY APPROACH

AM 8:00-8:30	Concord St SB				Concord St NB				Anzio Rd WB								INT. AVERAGE	
	Left	Thru/Gen	Right		Left?	Thru/Gen	Right?		Left?	Thru/Gen	Right?		Left?	Thru/Gen	Right?		TOTAL	CRITICAL
1	1	10				25			3	0		b						
2	2	6				19		a	3	0		b						
3	1	20				29			8	1								
4	0	14				17		a	10	0		b						
5	1	9				17		a	11	4								
6	0	7				30		a	9	1								
7	0	13				19			8	2								
8	0	5				21			10	0		b						
9	2	13				26			11	1								
10	0	17				16			11	0		b						
11																		
12																		
13																		
MAX	2	20	0		0	30	0		11	4	0		0	0	0			
AVG	0.7	11.4	0.0		0.0	21.9	0.0		8.4	0.9	0.0		0.0	0.0	0.0		8.7	15.2

PM 4:40-5:15																	INT. AVERAGE	
	Left?	Thru/Gen	Right?		Left?	Thru/Gen	Right?		Left	Thru/Gen	Right?		Left?	Thru/Gen	Right		TOTAL	CRITICAL
1	3	13				32		c	2	0								
2	3	14				23		c	6	0								
3	3	8				20		c	1	2								
4	3	9				30		c	4	0								
5	2	14				15		c	5	1								
6	2	10				16		c	7	0								
7	4	10				21		c	5	1								
8	3	9				18		c	6	0								
9	5	11				21		c	3	0								
10	4	8				13		c	8	1								
11						9		c										
12																		
13																		
MAX	5	14	0		0	32	0		8	2	0		0	0	0			
AVG	3.2	10.6	0.0		0.0	19.8	0.0		4.7	0.5	0.0		0.0	0.0	0.0		8.0	5.6

/metrowest/rt126/analysis/queues/Hartford126.xls

a: School crossing guard at Thelma Road stopped traffic for students.
b: Excludes right-turns-on-red, which are a large proportion of movements.

NOTES:

INTERSECTION QUEUES

PROJECT: MetroWest Subregional Study
LOCATION: Route 126 (Concord Ave) at Everit/Dennison
Framingham

DATE: 12/2/99AM;10/6/99PM
DAY: Wednesday
BY: MPM

OBSERVED QUEUE LENGTHS PER CYCLE BY APPROACH

AM 7:20-7:50

	Concord St SB			Concord St NB			Everit St WB			Dennison Rd EB			INT. AVERAGE	
	Left	Thru/Gen	Right	Left?	Thru/Gen	Right?	Left?	Thru/Gen	Right?	Left?	Thru/Gen	Right?	TOTAL	CRITICAL
1		9			2			3			1			
2		4			2			0			1			
3		1			3			3			1			
4		1			13			1			1			
5		8			15			2			0			
6		5			3			0			0			
7		0			17			3			1			
8		4			19			4			0			
9		8			12			2			0			
10		4			8			3			2			
11														
12														
13														
MAX	0	9	0	0	19	0	0	4	0	0	2	0		
AVG	0.0	4.4	0.0	0.0	9.4	0.0	0.0	2.1	0.0	0.0	0.7	0.0	4.2	3.3

PM 4:00-4:40

	Concord St SB			Concord St NB			Everit St WB			Dennison Rd EB			INT. AVERAGE	
	Left?	Thru/Gen	Right?	Left?	Thru/Gen	Right?	Left	Thru/Gen	Right?	Left?	Thru/Gen	Right	TOTAL	CRITICAL
1		11			4			3			2			
2		9			3			1			0			
3		4			2			0			2			
4		13			1			1			0			
5		10			1			0			3			
6		9			5			0			1			
7		7			13	a		3			3			
8		12			9			0			1			
9		7			7			1			1			
10		8			4			1			2			
11		10			2			2			1			
12		5			4									
13														
MAX	0	13	0	0	13	0	0	3	0	0	3	0		
AVG	0.0	8.8	0.0	0.0	4.6	0.0	0.0	1.1	0.0	0.0	1.5	0.0	4.1	4.9

/metrowest/rt126/analysis/queues/Dennison-126.xls

a: Actuated left-turn, so no zeros?
b: Several times, SB backup from downtown extended to/beyond Lincoln Street

NOTES: Northbound vehicles blocked by queues extending back from downstream intersection (Anzio)

MEMORANDUM

TO: **MetroWest Files** **September 1, 2000**

FROM: **Mary P. McShane**

RE: **MetroWest Subregional Area Study Tech. Memorandum #3: Route 9/Route 27 Interchange, Natick**

1. Introduction

The interchange of Route 9 with Route 27 (North Main Street) in Natick was originally designed to accommodate low-speed low-volume traffic but is subject to much greater strains by today's demands. The bridge which carries Route 27 over Route 9 is scheduled to be replaced by MassHighway. No additional improvements are currently planned for ramps or feeder road connections as part of the bridge replacement.

The desirability of such additional improvements was identified as an issue by the Natick Town Planner during Phase I of the MetroWest study. Traffic growth associated with commercial development along Route 9 has created congestion, long queues, and delays within the interchange. Because the planned bridge reconstruction may provide opportunities for additional improvements at this location, current operations were investigated, problems identified, and modification options examined. This memorandum documents the results of these investigations.

2. Study Area

For this analysis, the study area was taken to be the immediate area of the Route 9/Route 27 interchange only, extending along North Main Street from the Rutledge Road intersection on the north to the Bacon Street intersection on the south (**Figure 1**).

The interchange itself is similar to the cloverleaf type, in that it has directional lanes for all movements on and off Route 9; but these movements are accommodated via 2-way roadways, compressed within a very tight area. The ramps on the eastbound side are very short with tight turning radii and "Yield" signs at their termini on Route 27. On the westbound side, the ramps are elongated in a north-south direction, and have intersecting driveways and one intersecting street. The northwest quadrant is particularly complicated, with on and off ramps which transition to a 2-way roadway with intersecting turning bays, providing access onto Route 27 and into abutting properties, and an intersection with Lake Shore Road. Traffic entering and exiting Route 9 via these ramps conflicts with local traffic to and from these properties (Fannon's Liquor Store and the adjacent office buildings) as well as the Lake Shore Road neighborhood, which has its only

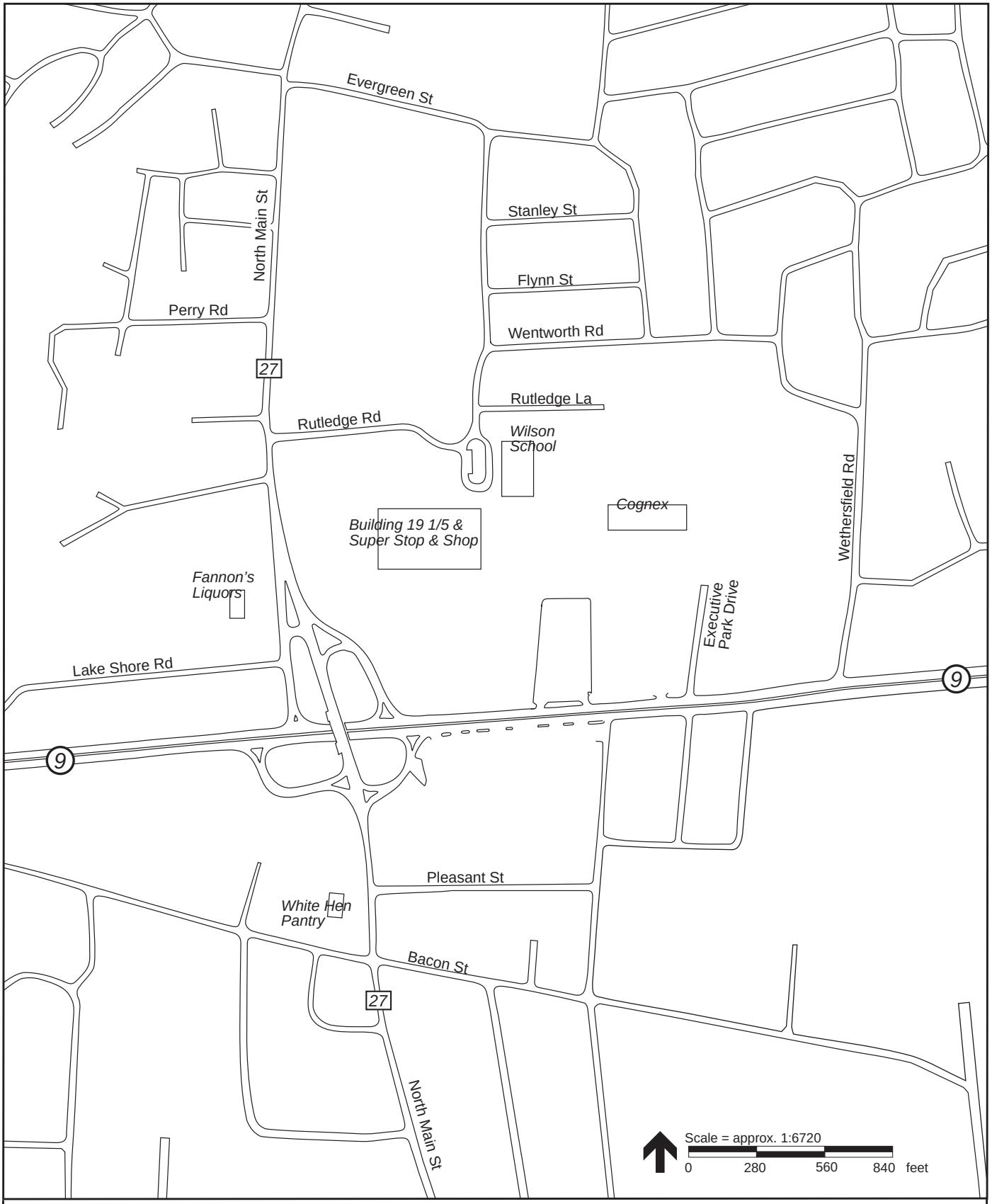


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Figure 1
Route 9/27 Interchange: Location Map

MetroWest/P_Rt27Natick/Report/Graphics/fig_1.FHD

access via the ramps.[1] Several of these intersections in this quadrant are uncontrolled; but a flashing red / yellow light stops traffic making left and right turns from the westbound off- ramp, Lake Shore Road and local businesses onto Route 27.

The northeast quadrant is the site of a Building 19 1 / 5 warehouse store, as well as a Super Stop & Shop supermarket and other small retail uses (referred to in analysis tables as "the Mall"). Access to these properties is provided via the signalized intersection just south of Rutledge Road, as well as by a direct right-in, right-out, driveway located on the Route 9 Westbound off-ramp, an unusual and substandard configuration. Traffic exiting the Mall area and destined for Route 9 Eastbound or Westbound must use the signalized intersection. The exit approach area is channelized only in the area close to the signal, and vehicles queue rather haphazardly upon exiting during the busy PM peak period. A southbound left-turn lane and a northbound right-turn lane are provided on Route 27 at this signalized intersection to facilitate movements into the shopping area.

Rutledge Road is a two-way local street which provides access to two schools and a residential neighborhood on the north side of Route 9. It also is a turning point for eastbound Route 9 traffic using the Route 27 interchange to access Executive Park Drive, on the westbound side of Route 9. The intersection of Rutledge Road with Route 27 is an uncontrolled T intersection, with a gas station / garage on one corner and a small commercial area on another. There are no sidewalks on this section of Rutledge Road, and the angle parking in front of the commercial area / laundromat is not separated by curbing from the traveled way of the street.

Bacon Street is a narrow two-way street which traverses a residential neighborhood, but which also appears to serve as a parallel route to Route 9 for some traffic. Its intersection with Route 27 is signalized, and there are sidewalks and curbing on all four quadrants. The northwest quadrant is occupied by a White Hen Pantry and its parking; the store has access driveways on both North Main Street and Bacon Street. Northbound traffic making a left turn to enter the store occasionally blocks through traffic while waiting for a gap in the opposing traffic stream. More problematic is the blockage which occurs to southbound traffic as a result of vehicles waiting to turn left into Bacon Street, especially during the PM Peak Period. Through vehicles cannot effectively bypass even a single vehicle waiting to make this left turn. The result is that traffic queues regularly back up to and beyond the Route 9 eastbound off-ramp.

The primary issues of interest in this area include the following:

--reducing vehicle conflicts and confusion caused by unusual interchange design.
--alleviating chronic queuing, especially for southbound traffic in PM Peak.

Town officials have also expressed concern that anticipated additional office development at Cognex, located on Executive Park Drive with access only from Route 9 Westbound, will

[1]In the past, Lake Shore Road itself on its westerly end provided a direct ramp-type connection to Route 9 Westbound; this connection has been closed off by concrete barriers, presumably at the request of local residents.

result in further traffic volume increases at the Route 9/Route 27 interchange. Currently, some Route 9 traffic from the west, destined for the Cognex site, uses the Route 27 interchange to exit Route 9 and proceed to Cognex using local streets. The likely incremental impact of such added development is an issue to the Town, which is interested in exploring a possible "back-door" entrance into Cognex from Roue 27, using Rutledge Road and Rutledge Lane.

3. Existing Conditions

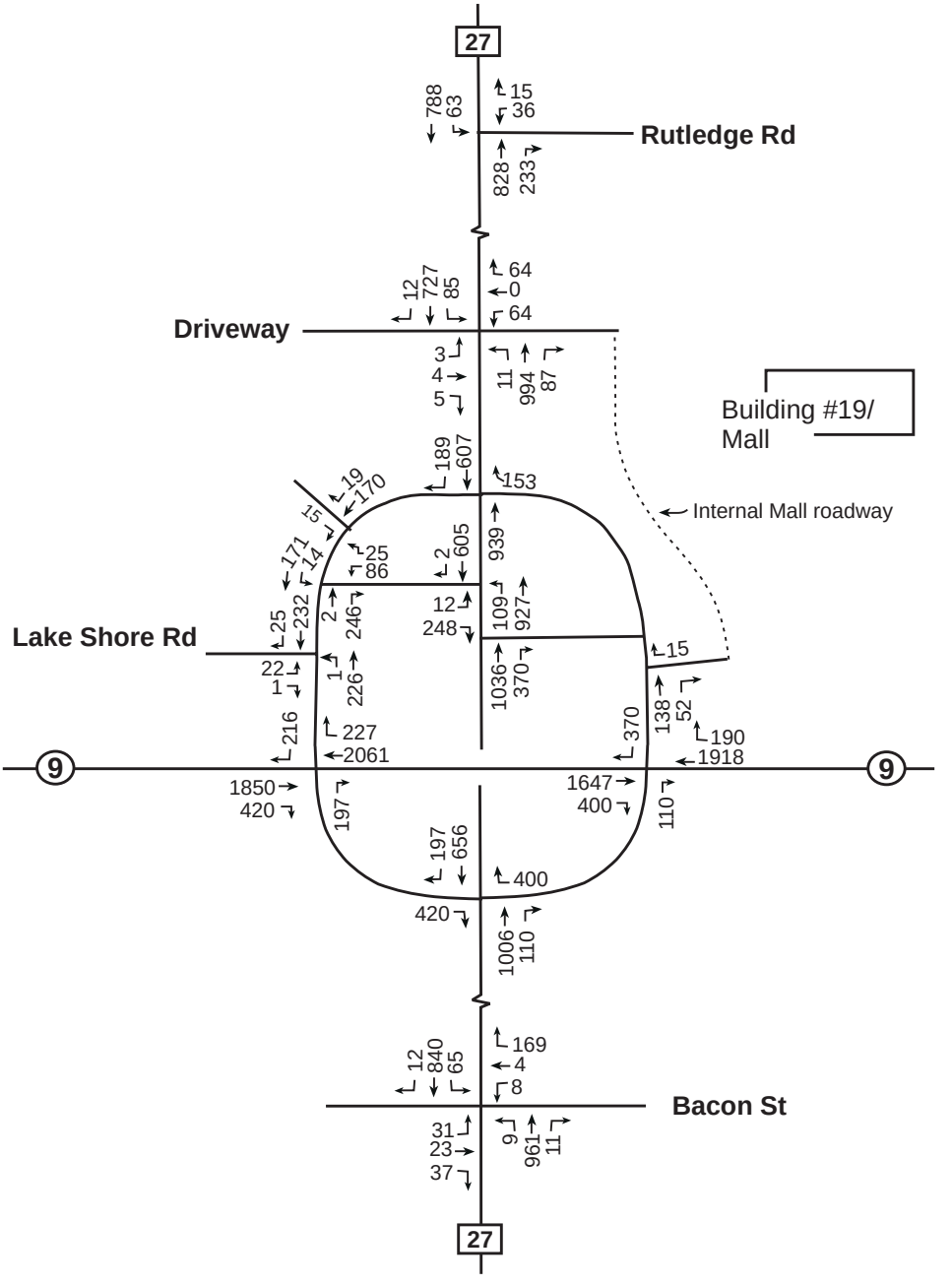
3.1. Observations

Observations were made of existing traffic at the interchange during Fall 1999, including peak-period traffic counts at several locations, and queue measurements at the two existing signalized intersections (Route 27/Bacon Street and Route 27/Mall Driveway). **Figures 2** and **3** illustrate existing AM and PM peak hour traffic volumes at the interchange and intersections. **Appendix A** contains newly-collected traffic counts and geometric data for key intersections.

As the counts indicate, volumes on Route 27 are fairly high, exceeding 1000 vehicles per hour in a single travel lane at several locations, with the greatest intensity in the immediate vicinity of the interchange. The Building 19/Super Stop & Shop Mall generates very little traffic during the morning, but is a major generator during the evening peak. The volume entering Rutledge Road from Route 27 Northbound during the morning is partly associated with student drop-offs at one or both of the area schools. The most intense interval for school arrivals appears to occur between 7:30 and 7:45 AM. In addition, some traffic does appear to be using Rutledge Road to access Executive Park Drive, as described above.

Queue measurements were undertaken at the two signalized intersections, by observing each approach through 10 cycles, and noting the maximum and average queue lengths. The limit of measurement for long queues was about 30-32 vehicles—beyond that length, the queue and the signal causing it generally could not be observed simultaneously. **Table 1** summarizes measured queue lengths, while **Appendix A** includes the complete queuing data.

The *average* stopped queue lengths at the Route 27/Mall Driveway signalized intersection do not appear to be excessive (up to 9 vehicles), although *maximum* stopped queues of 15-18 vehicles were observed on Route 27 Northbound during both peak hours. The primary concern for northbound queues at this location is that they tend to create blocking/merging problems for exiting movements from the Route 9 Westbound-to-Northbound off-ramp, about 450 feet south of the signal. The traffic stream from this off-ramp as it approaches Route 27 consists almost entirely of through northbound traffic--few, or no, vehicles from this stream intend to turn right into the Mall at the signal, since they have already gone past their first opportunity to enter the Mall (i.e., the driveway located on the ramp). Thus, almost all the off-ramp traffic needs to move into the through northbound lane. This movement requires exiting the ramp into the right-turn lane, then merging into the through lane before the signal—a maneuver which is quite difficult in the short distance available, especially when the signal queues are long.



Adjusted Counts, June-November 1999

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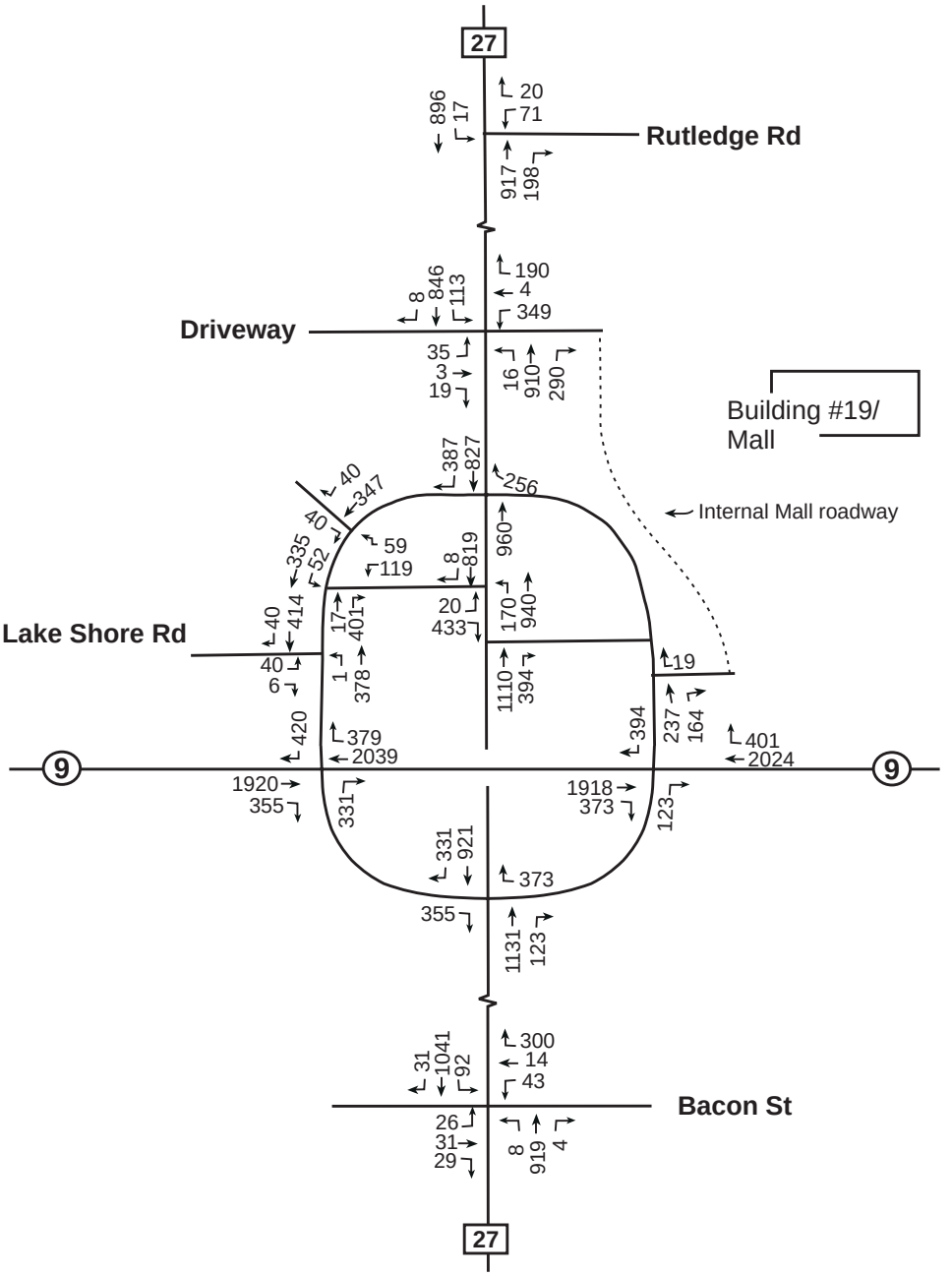
Figure 2
Existing AM Peak Hour Volumes (1999)

MetroWest/P_Rt27Natick/report/graphics/fig_2.cdr



Adjusted Counts, June-November 1999

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Figure 3

Existing PM Peak Hour Volumes (1999)

MetroWest/P_Rt27Natick/report/graphics/fig_3.cdr

TABLE 1
Existing Conditions – Measured and Calculated Queue Lengths

Signalized Intersection	Measured Queue* (ft)		Calculated Queue (ft)		LOS†
	Avg	Max	50%-ile	95%-ile	(delay, sec)
AM PEAK HOUR					
Route 27 at Bldg 19 Mall—OVERALL					A (7.9)
Business EB LTR	(n/a)	(n/a)	1	9	C (23.8)
Mall WB LT	40	75	32	67	C (32.0)
Mall WB R	(n/a)	(n/a)	0	16	A (6.8)
N.Main NB LT	155	375	300	699#	B (10.9)
N.Main NB R	(n/a)	(n/a)	0	14	A (1.2)
N.Main SB L	(n/a)	(n/a)	6	35	A (4.7)
N.Main SB TR	62	200	90	191	A (2.7)
Route 27 at Bacon St—OVERALL					A (9.4)
Bacon EB LTR	35	75	29	71	C (21.7)
Bacon WB LTR	88	150	6	61	A (6.7)
N.Main NB LTR	160	375	182	476	A (6.8)
N.Main SB LTR	93	225	201	699#	B (11.6)
PM PEAK HOUR					
Route 27 at Bldg 19 Mall—OVERALL					C (24.2)
Business EB LTR	(n/a)	(n/a)	15	46	B (17.2)
Mall WB LT	125	250	189~	361#	E (71.9)
Mall WB R	80	175	28	73	A (8.2)
N.Main NB LT	212	450	427	714#	C (31.0)
N.Main NB R	10	100	0	23	A (1.2)
N.Main SB L	35	75	19	84#	B (16.1)
N.Main SB TR	142	750	230	360	A (9.9)
Route 27 at Bacon St—OVERALL					D (49.7)
Bacon EB LTR	23	50	28	72	C (22.0)
Bacon WB LTR	120	225	92	249#	C (25.1)
N.Main NB LTR	150	425	235	405	A (8.6)
N.Main SB LTR	483	800-*plus*	792~	1038#	F (92.0)

Table 1 (cont'd)

† Calculated by Synchro, which uses the 1997 HCS methods to calculate Levels of Service and delays. These are different from the methods used by MassHighway, based on the 1994 Manual.

* Measured queue lengths based on field measurements of 10 signal cycles per approach in AM/PM peak periods during October/November 1999. Queue measurements are shown in feet, with assumed average vehicle length of 25 feet—thus, 225 feet represents 9 queued vehicles. Synchro calculates maximum queue lengths on (a) a typical cycle (50^{th} percentile) and (b) the 95^{th} percentile cycle (i.e., that with vehicle arrival rate greater than 95 percent of all cycles during the analysis period—only 5 percent of all signal cycles experience a greater arrival rate).

95^{th} percentile: volume exceeds limits of queuing formulas; value shown represents queue after 3 minutes, and is typically greater than queues actually experienced.

~ 50^{th} percentile: volume exceeds capacity on average; queue is theoretically infinite; value shown is sufficient to accommodate one cycle of traffic.

In addition, it is worth noting that the exiting lanes at the Mall Driveway are only channelized and marked for a short distance. In the evening peak hour, exiting vehicles exceed the capacity of this area, and queue back in the Mall's internal roadway. The lack of curbing or other definition of the edge of this roadway encourages queue-jumping and bunching of vehicles at the exit, which contributes to delay at the signal.

Queuing issues are more severe at the intersection of Route 27 and Bacon Street. The main problem occurs because there is no separate storage for southbound left turns at this intersection. The numbers of these turns are not high, in morning or evening; but the volumes of through traffic *are* high, and just a few left turns are enough to cause back-ups beyond the Route 9 ramps. The average queue length measured in the PM peak hour observation period was 19+ vehicles, and the maximum queue extended beyond the limits of measurement.

3.2. Analysis

Conditions at the study area ramp junctions and intersections were analyzed using the Synchro computer program and the capacity analysis procedures of the 1994 Highway Capacity Manual. Synchro is a program developed to optimize traffic signal systems, and is better suited to networks of signalized intersections than unsignalized. However, it incorporates a direct method for estimating queue lengths at signalized intersection approaches—both 50^{th} percentile and 95^{th} percentile queues—which CTPS has found to be reasonably accurate, especially for non-saturated conditions. In addition, it offers the capability to perform simulations of traffic operations using a geometrically correct network, so that one can at least see (if not analyze) the potential queue developments at non-signalized locations. Consequently, the interchange and its environs were modeled using this software (interchange geometry shown in **Figure 4**).

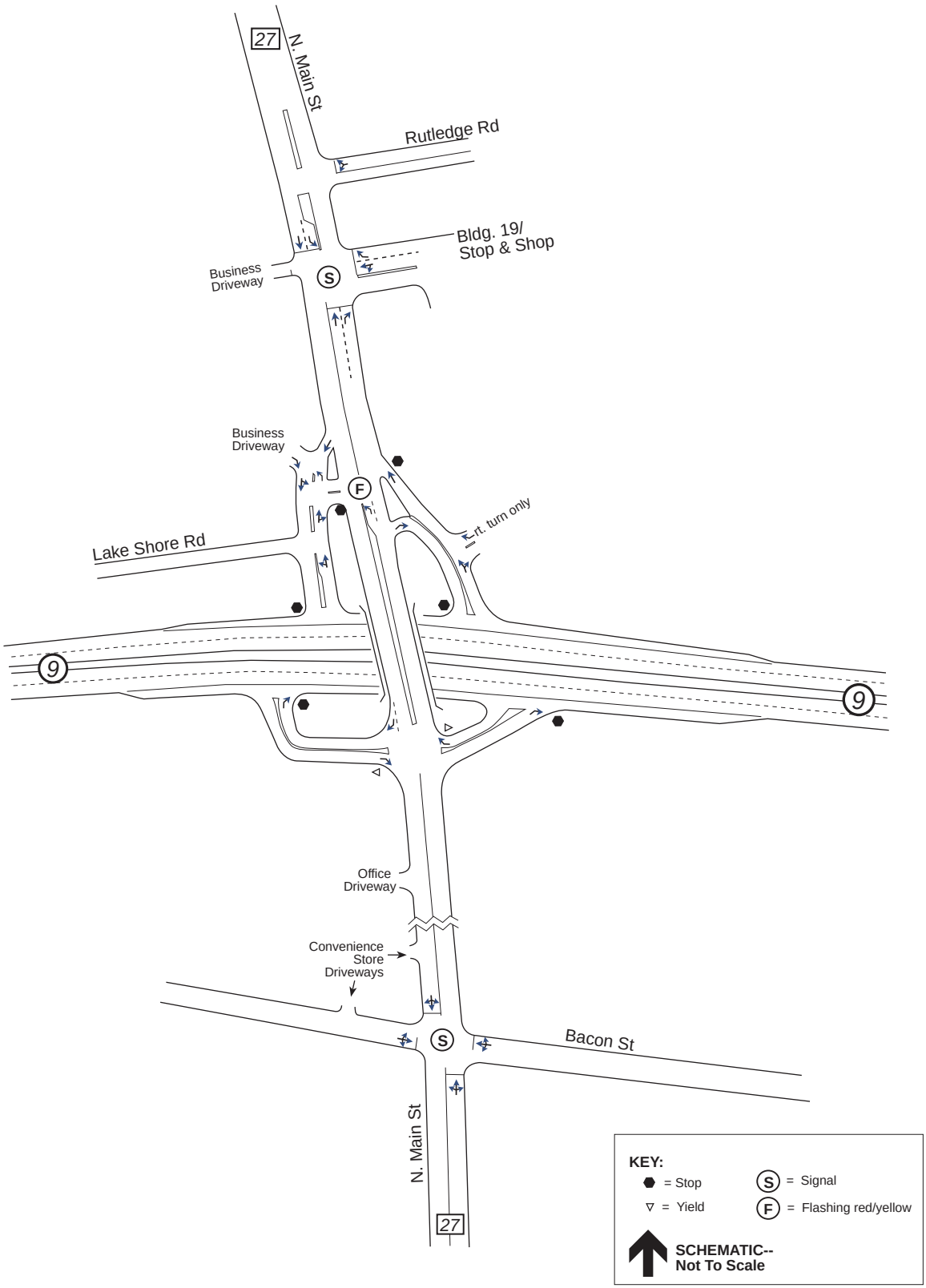

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Figure 4
Existing Lane Configuration

MetroWest/P_Rt27Natick/report/graphics/fig_4.FHD

The Level of Service results produced by Synchro for existing conditions are displayed in **Table 1**. These results show "very good" operations for both signalized intersections in the AM Peak Hour, and "adequate/acceptable" operations in the PM Peak Hour. The only major approach shown as failing is the single-lane Route 27 southbound approach to Bacon Street in the PM Peak, which is at LOS F primarily because small numbers of left-turning vehicles regularly block high volumes of southbound through traffic.

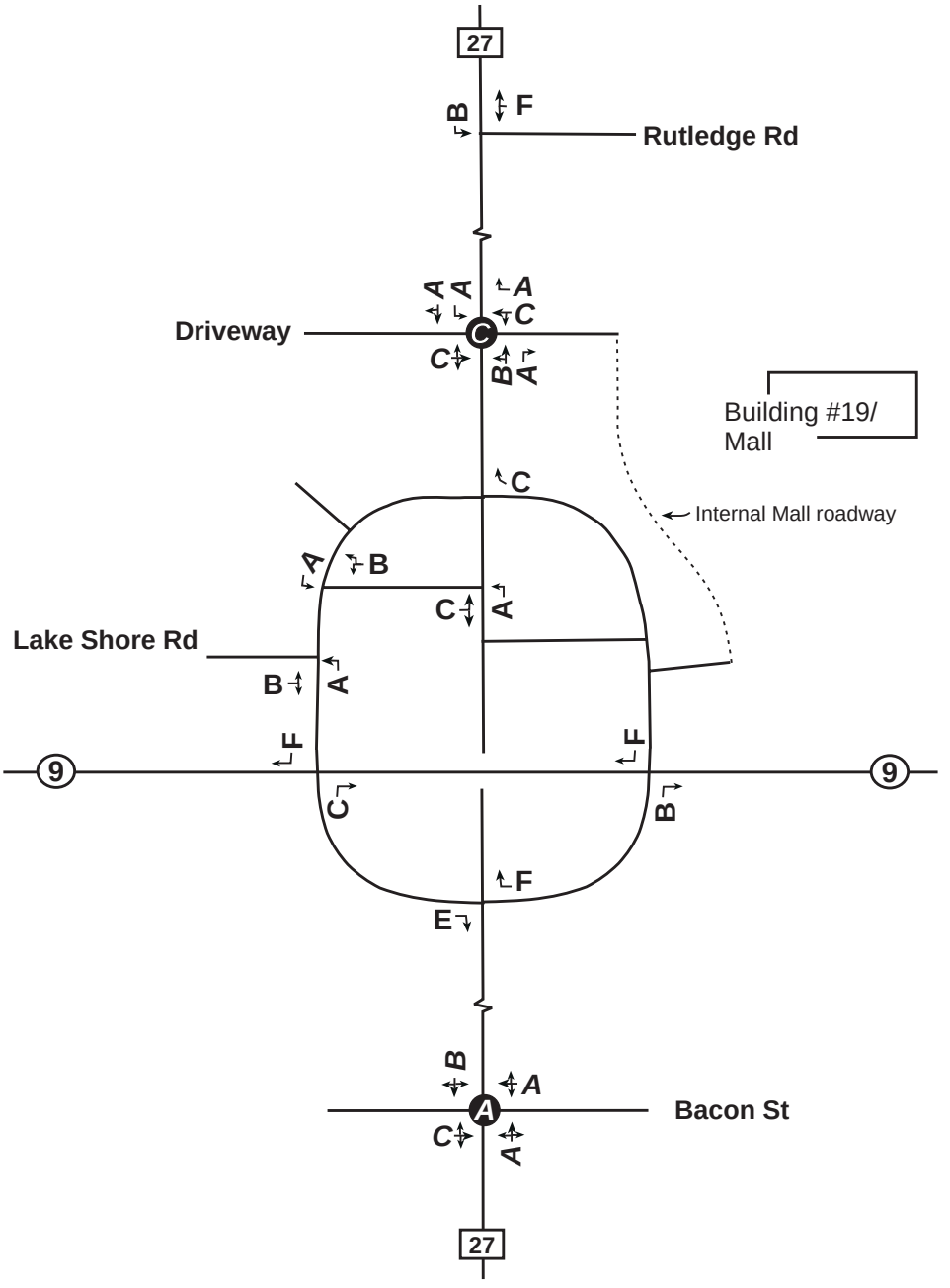
The results of the Synchro calculation of existing queues for at these intersections are also summarized and compared with *measured* queue lengths in **Table 1**. A degree of variability can be seen in the queue lengths reported: the calculated values tend to be fairly close to the measured values for shorter queues. However, at longer queue lengths, the Synchro analysis tends to yield estimates which are higher, sometimes substantially higher, than the measured queue lengths, for several reasons.[2] In addition, lanes which are not designated exclusive right-turn lanes may nevertheless serve largely right-turning traffic, and may permit a lot of right-turn-on-red movements which are not counted in the measured queue length.

Despite the limitations of the *absolute values* calculated by the Synchro method, the queue analysis procedures provide useful guidance about the potential for queuing on approaches serving moderate-to-high traffic volumes. In particular, these procedures may provide information on the *relative* impacts of alternative signal timing patterns and roadway configurations, as long as existing conditions are first validated with field measurements to provide a base case for the comparison.

In addition to Synchro, the procedures of the 1994 Highway Capacity Manual were applied using HCM software to calculate Levels of Service at *un*signalized intersections for AM and PM Peak Hours.

The results of the Level of Service analysis using HCS are summarized in **Figures 5** and **6**. Generally, vehicles on minor streets and ramps experience difficulty making turns onto major streets at unsignalized intersections. Thus, traffic exiting Rutledge Road during both peak hours is at LOS F, primarily because of delays to left turns caused by heavy two-directional traffic on Route 27. Several of the ramp entrances to Route 9 are at LOS F during one or both peak hours. The ramps on the eastbound side of Route 9 are also at LOS E/F at their intersections with Route 27, in both peak hours, as is the intersection of the turning bay from Fallon's and the westbound off-ramp with Route 27.

[2] i.e., difficulty in measuring queues which extend a long distance away from the stop light, and difficulty in determining where is the end of a long queue whose last vehicles are moving slowly, never fully stopped.



LOS Value

D *Unsignalized Intersections -- individual movements*

C *Signalized Intersections -- individual movements*

B *overall intersection*

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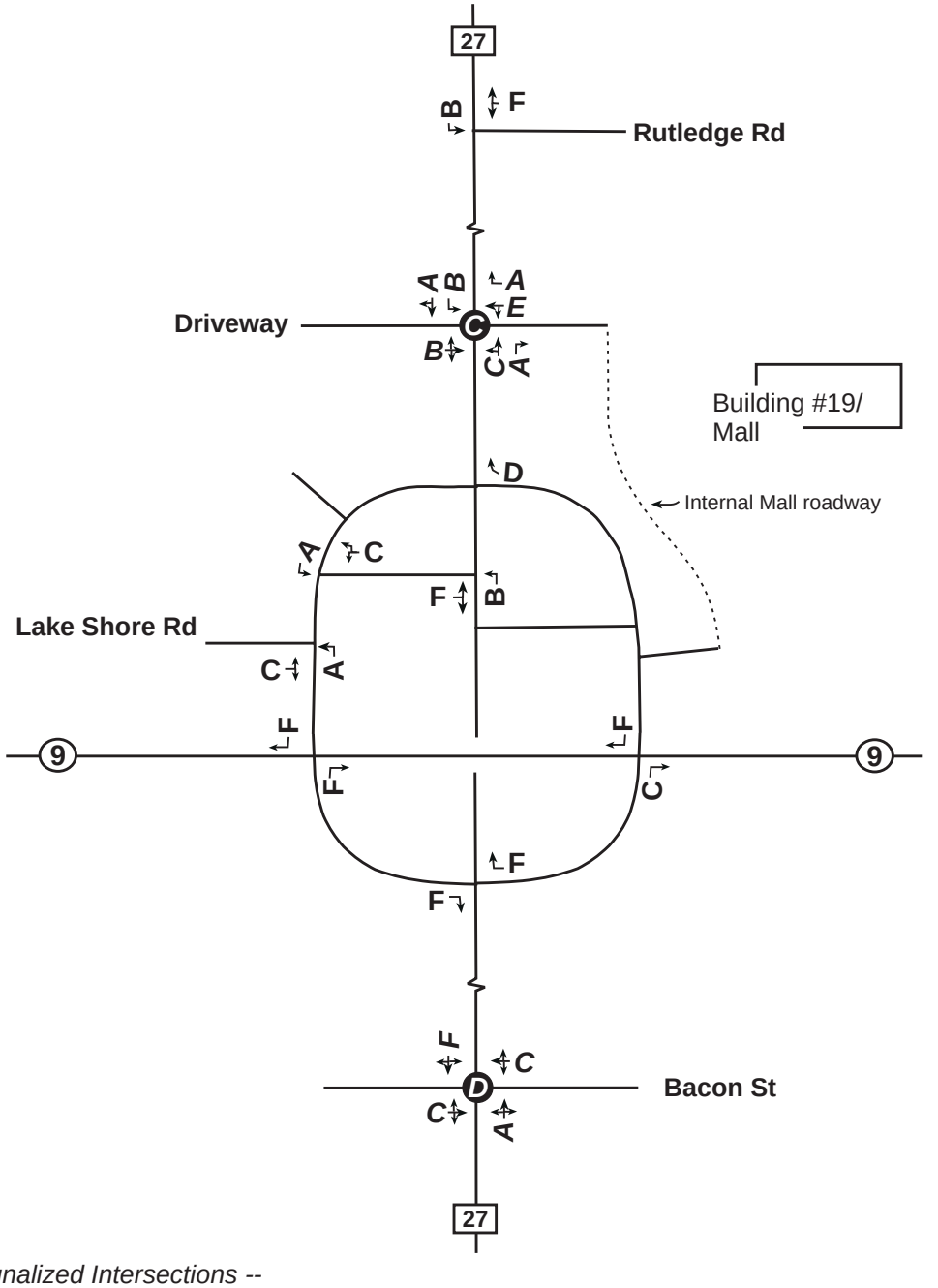
Figure 5
Existing AM Levels of Service (1999)

MetroWest/P_Rt27Natick/report/graphics/fig_5.cdr



LOS Value	
D	*Unsignalized Intersections -- individual movements*
C	*Signalized Intersections -- individual movements*
B	*overall intersection*

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Figure 6
Existing PM Levels of Service (1999)

MetroWest/P_Rt27Natick/report/graphics/fig_6.cdr

4. Types of Improvements Investigated

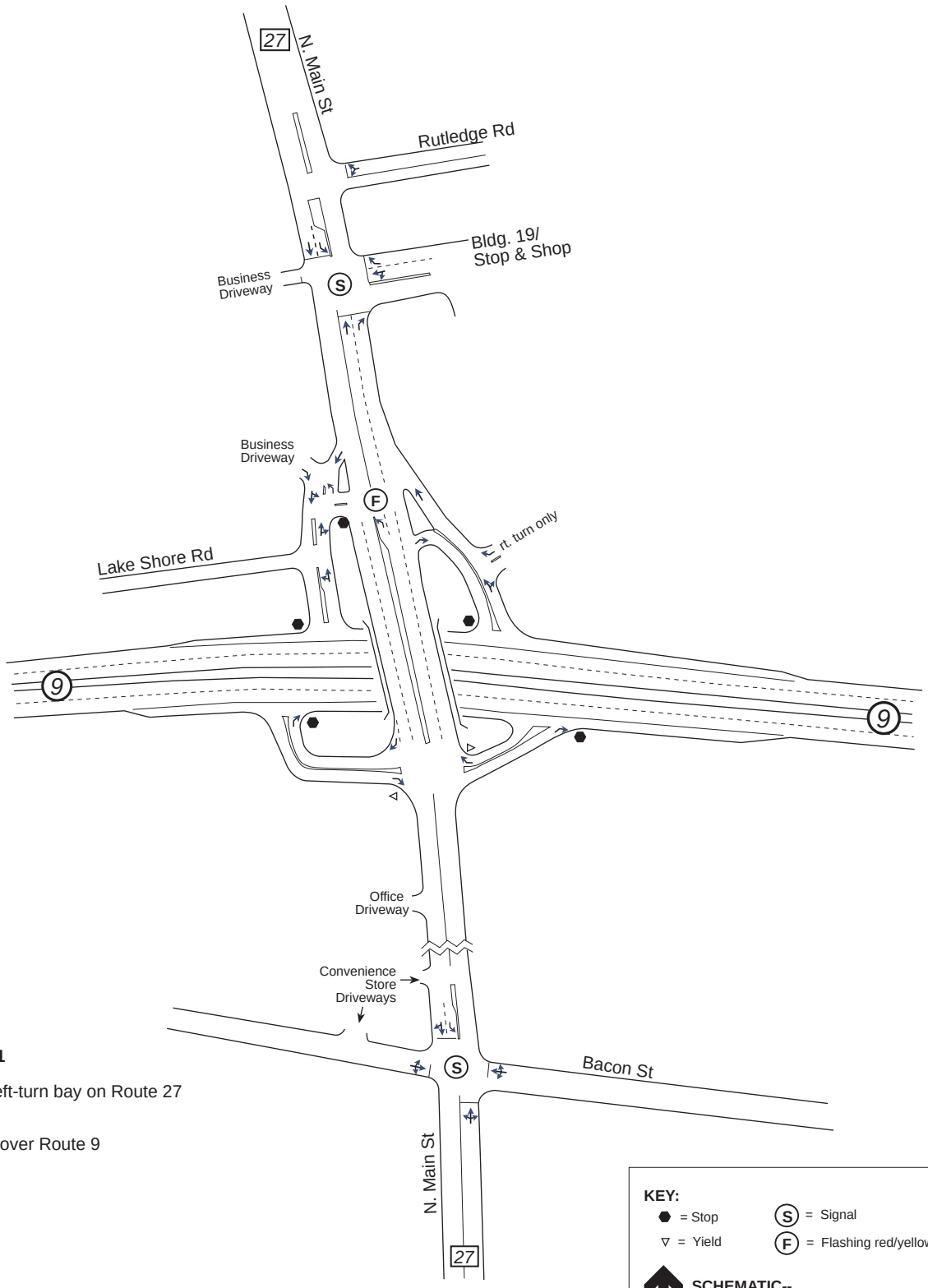
Ideally, it would be possible to replace the existing interchange completely, and provide new ramps which meet modern design standards. However, the area of the existing interchange is extremely constrained by existing development. Any major reconstruction of ramps here would be extremely expensive, and would involve major takings of commercial and possibly residential property. Several options for improvement, short of total rebuilding, do exist. Some of these include:

a. provision of a southbound left-turn slot on Route 27 at Bacon Street to allow through traffic to bypass left-turn queues, especially during the evening peak period.
b. rebuilding the bridge over Route 9 as a 4-lane bridge.
c. together with (b), widening the section of Route 27 Northbound between the interchange and the signalized Mall Driveway, tapering back to one lane north of Rutledge Road.
d. consolidating some of the turning movements at the interchange itself into a signalized intersection.
e. relocating one or more of the interchange movements to reduce weaving conflicts on Route 9 between the ramps.
f. restricting the existing Mall driveway located on the Route 9 Westbound off ramp to entering traffic, and requiring all traffic exiting the Mall to use the signalized intersection to the north.

These options were incorporated into 3 alternative packages which could represent plausible improvements for this interchange for the foreseeable future:

Alternative 1: includes widening the existing bridge to 4 travel lanes, and providing a southbound left-turn bay at the intersection of North Main Street and Bacon Street, to relieve the most obvious problem in the vicinity of the interchange (**Figure 7**).

Alternative 2: includes **Alternative 1**, with North Main Street roadway widening extended to include 2 through northbound lanes as far as Rutledge Road, and 2 southbound lanes south of the Route 9 Westbound ramp diverge. This option is intended to provide additional storage room for queued traffic close to the interchange and to improve the operation of northbound traffic from the Route 9 off-ramp weaving with northbound traffic destined for the Mall (**Figure 8**).



ALTERNATIVE 1

- o southbound left-turn bay on Route 27 at Bacon St.
- o 4-lane bridge over Route 9

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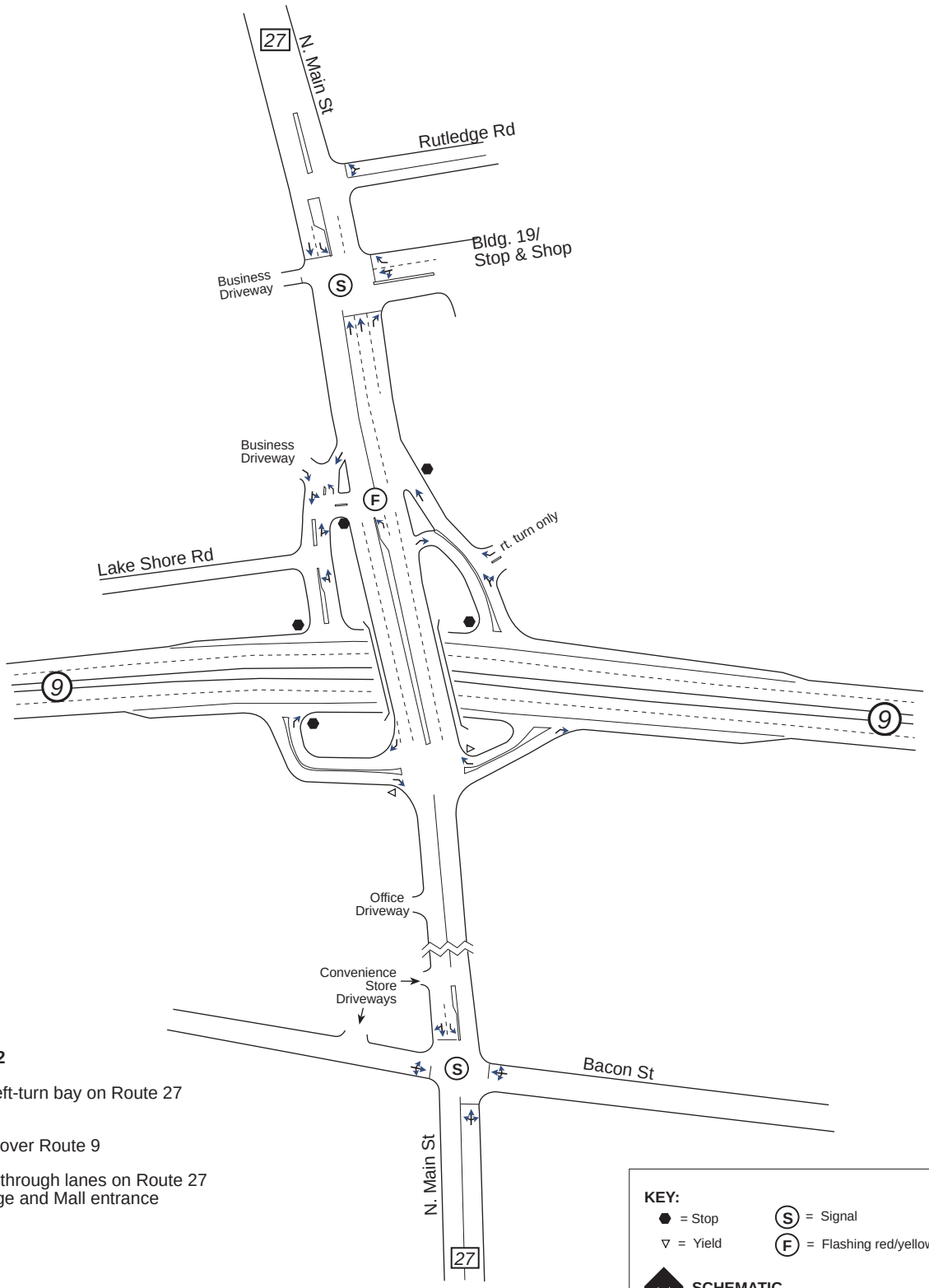
Figure 7
Improvement Alternative 1

MetroWest/P_Rt27Natick/report/graphics/fig_7.FHD



ALTERNATIVE 2

- o southbound left-turn bay on Route 27 at Bacon St.
- o 4-lane bridge over Route 9
- o 2 northbound through lanes on Route 27 between bridge and Mall entrance

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Figure 8
Improvement Alternative 2

MetroWest/P_Rt27Natick/report/graphics/fig_8.FHD

Alternative 3: is a more radical reworking of the connections to and around the interchange. It includes a 4-lane bridge, but eliminates the Route 9 Westbound on-ramp on the west side of the interchange. All traffic exiting Route 9 Westbound would use the existing ramp on the east side of the interchange. In addition, a new signalized intersection would be created just north of the bridge, at the location of the existing flashing red / yellow light, to accommodate left-turning traffic from the Westbound off-ramp; and traffic from Lake Shore Road would also be directed through this intersection. The purpose of these modifications would be to eliminate the weave between entering and exiting traffic on Route 9 Westbound and to simplify the interaction between Lake Shore Road traffic and Route 9 on-ramp traffic.

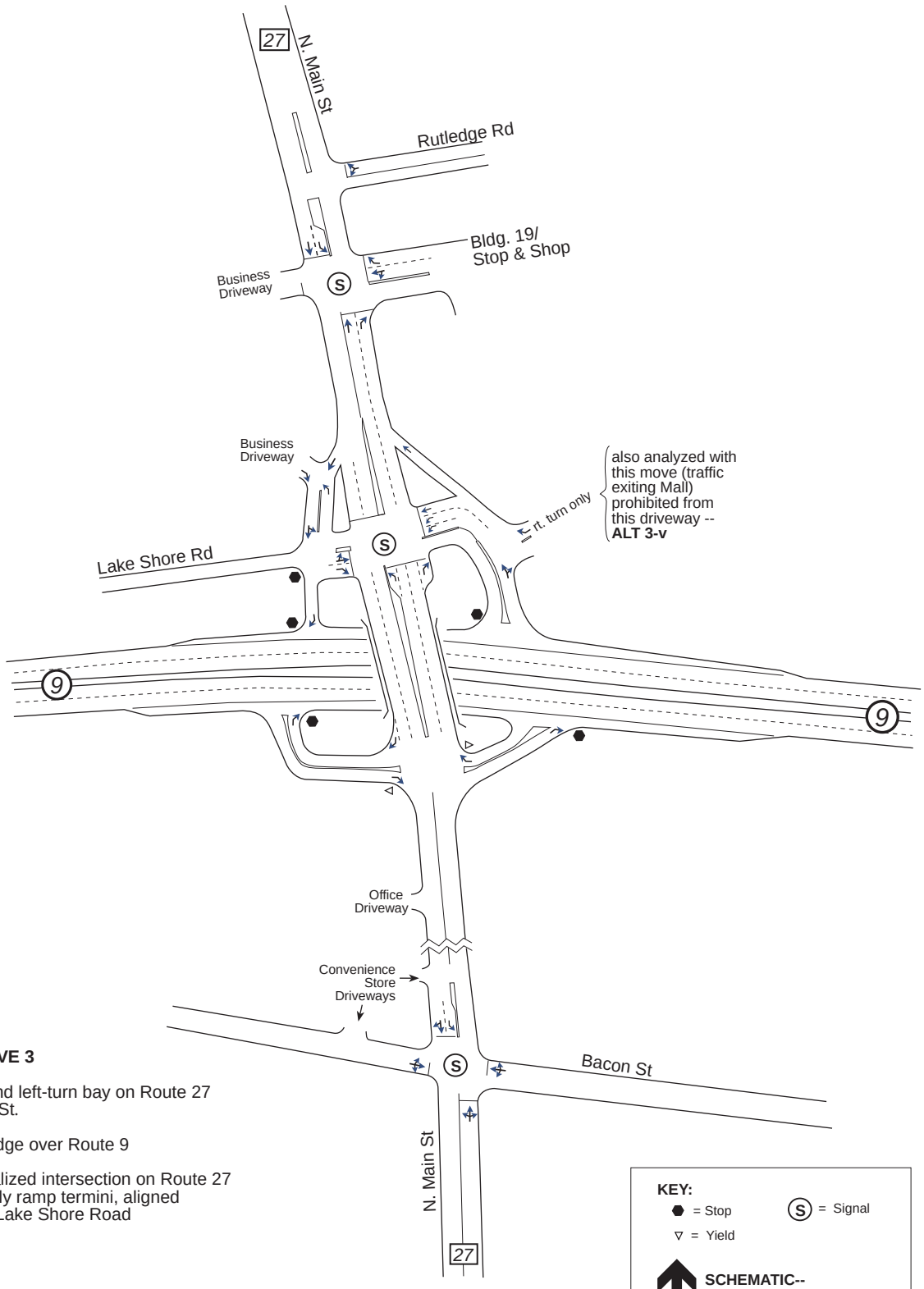
Figure 9 shows the geometry of this concept; **Figures 10-11** illustrate the traffic rerouting it would involve, assuming retention of the Mall driveway onto the Route 9 Westbound off-ramp. These modifications would provide a much closer connection to Route 9 East and West for traffic exiting the Mall—via the driveway onto the Route 9 Westbound off-ramp. This driveway would attract a large proportion of the traffic away from the signalized intersection at the principal Mall driveway, which currently represents the only exit for Route 9-bound traffic.

Because the resulting high volumes could easily become a queuing problem, a variant on **Alternative 3** was also analyzed for the PM Peak Hour only—**Alternative 3-v**, under which the Mall driveway located on the Route 9 Westbound off-ramp is restricted to prohibit outbound Mall-to-ramp movements, allowing only inbound Mall traffic. The location of such a driveway on an interchange ramp, serving *any* traffic, would not have been permitted under current design guidelines. We assume that eliminating the driveway entirely might not be a feasible option at present; and it is not heavily used for exiting traffic at present in any case. However, restricting its availability to traffic entering the Mall from Route 9 should be seriously considered as part of any improvement which would greatly increase the attractiveness of this driveway to traffic leaving the Mall.

In addition to the above, a longer-term alternative was investigated: replacement of the existing interchange with a "single-point diamond," which channels all turning movements to and from Route 9 into a single high-capacity signalized intersection. The scheme as depicted in **Figure 12** accomplishes several objectives:

1) it isolates access to and from Lake Shore Road and the nearby businesses from activities on the Route 9 on and off ramps, thereby simplifying these connections.

2) it effectively lengthens the available ramp area, so that queues can be accommodated without backups onto the Route 9 roadway in either direction. Lengthening the acceleration and deceleration areas on Route 9 would also greatly improve sight distances for entering and exiting vehicles, and may eliminate a major cause of rear-end collisions here. Also, a "single-point diamond" design would eliminate the short weaving areas along Route 9 between sequential on- and off-ramps, typically associated with cloverleaf-type interchanges.



ALTERNATIVE 3

- o southbound left-turn bay on Route 27 at Bacon St.
- o 4-lane bridge over Route 9
- o new signalized intersection on Route 27 at northerly ramp termini, aligned opposite Lake Shore Road

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Figure 9
Improvement Alternative 3

MetroWest/P_Rt27Natick/report/graphics/fig_9.FHD

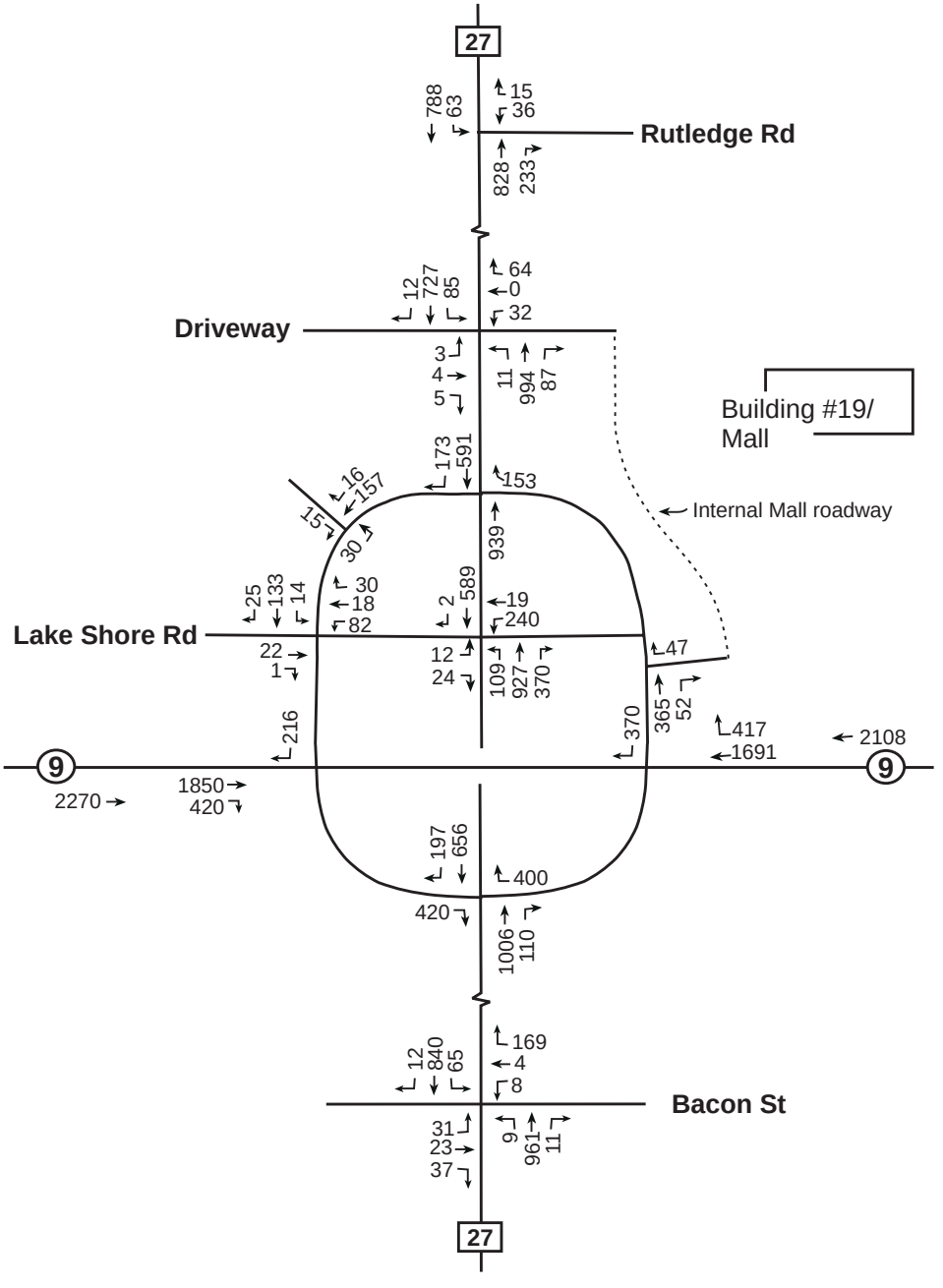

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Figure 10
Improvement Alternative 3: AM Peak Hour Volumes

MetroWest/P_Rt27Natick/report/graphics/fig_10.cdr

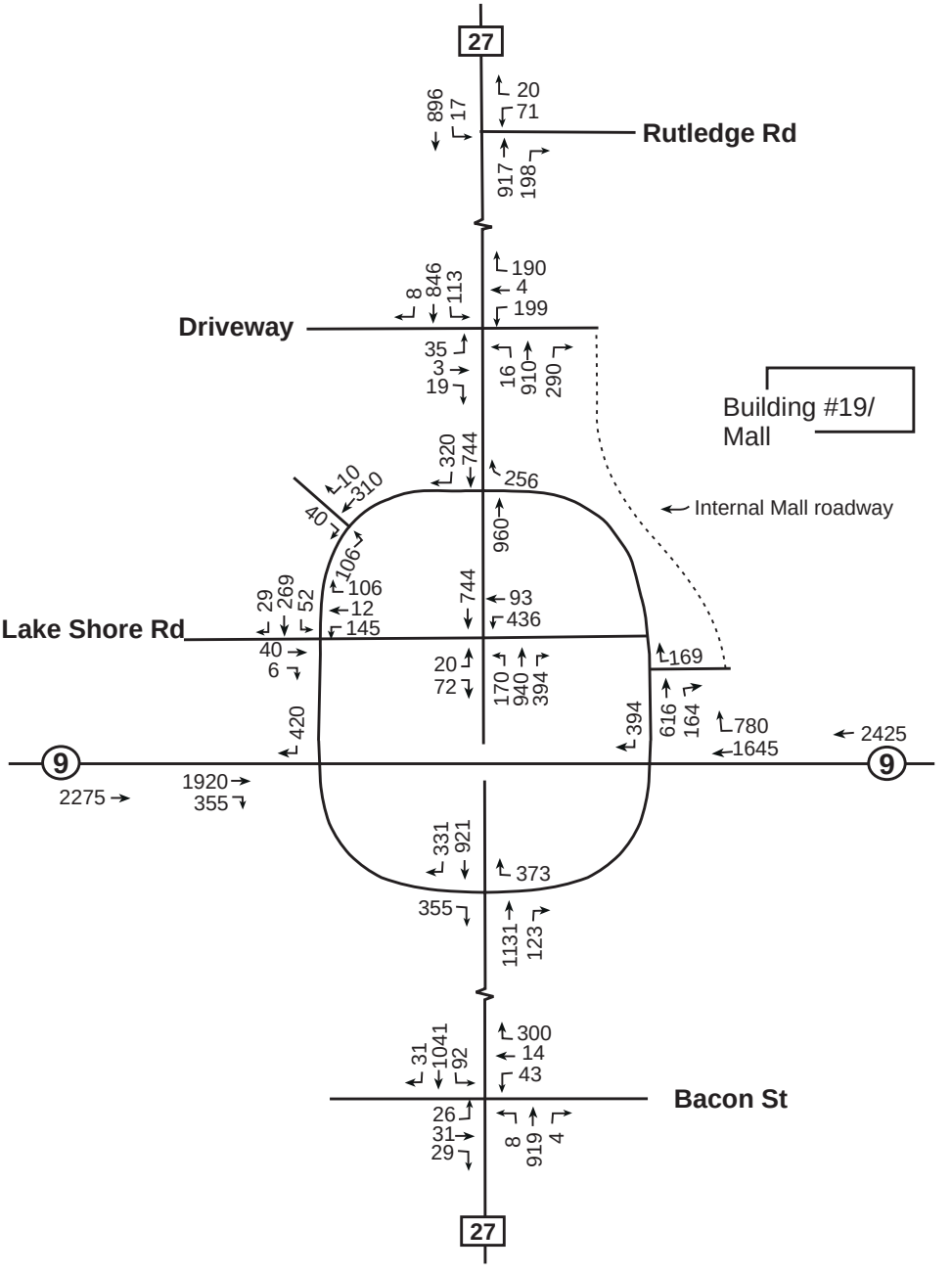

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Figure 11
Improvement Alternative 3: PM Peak Hour Volumes

MetroWest/P_Rt27Natick/report/graphics/fig_11.cdr

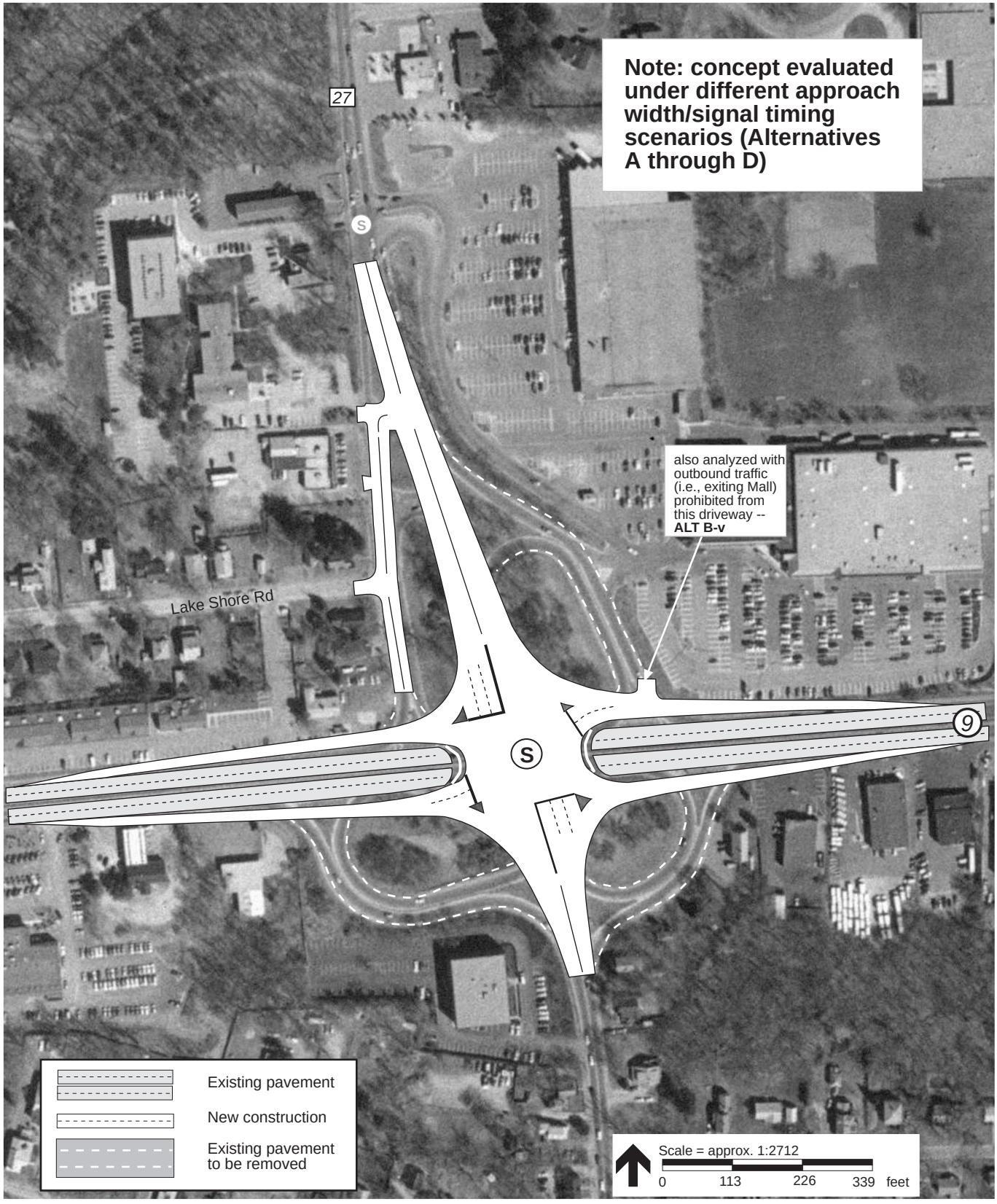

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Figure 12
General "Single-Point Diamond" Interchange Concept

MetroWest/P_Rt27Natick/report/graphics/fig_12.FHD

3) it provides additional capacity, but only within the immediate area of the interchange, not extended north or south along North Main Street. Thus, queuing conditions are greatly relieved in the area of the interchange itself, but the limited capacity of the major approaches does not encourage traffic growth.

4) it retains and improves upon existing connections to and from Building 19 and the shopping mall area.

Figures 13 and **14** show the rerouted traffic volumes associated with the "single-point diamond" concept.

Several minor variations on this concept were analyzed, to determine how much space would be required to obtain an acceptable Level of Service, including:

Alternative A: Single-point diamond with "split" signal phasing (i.e., each movement has a separate green phase).
Alternative B: Single-point diamond with "quad" signal phasing (8-phase dual-ring controller), with timings optimized by Synchro.
Alternative C: Same as B, but with additional turning lanes on major approaches.
Alternative D: Same as B, but with shorter cycle length.

In addition, a single-point interchange alternative, like **Alternative 3** above, would attract traffic bound for Route 9 which currently uses the signalized driveway to the north. Therefore, a variant on **Alternative B** was analyzed, for the PM Peak Hour only, assuming closure of the Mall driveway on the ramp to exiting traffic. This alternative is referred to as **Alternative B-v** in the result tables.

However, it is acknowledged that, even if any one of **Alternatives A** to **D** were regarded as a desirable alternative by Natick officials and residents, the land-taking, displacement and disruption associated with such a scheme would render it a long-term possibility, at best.

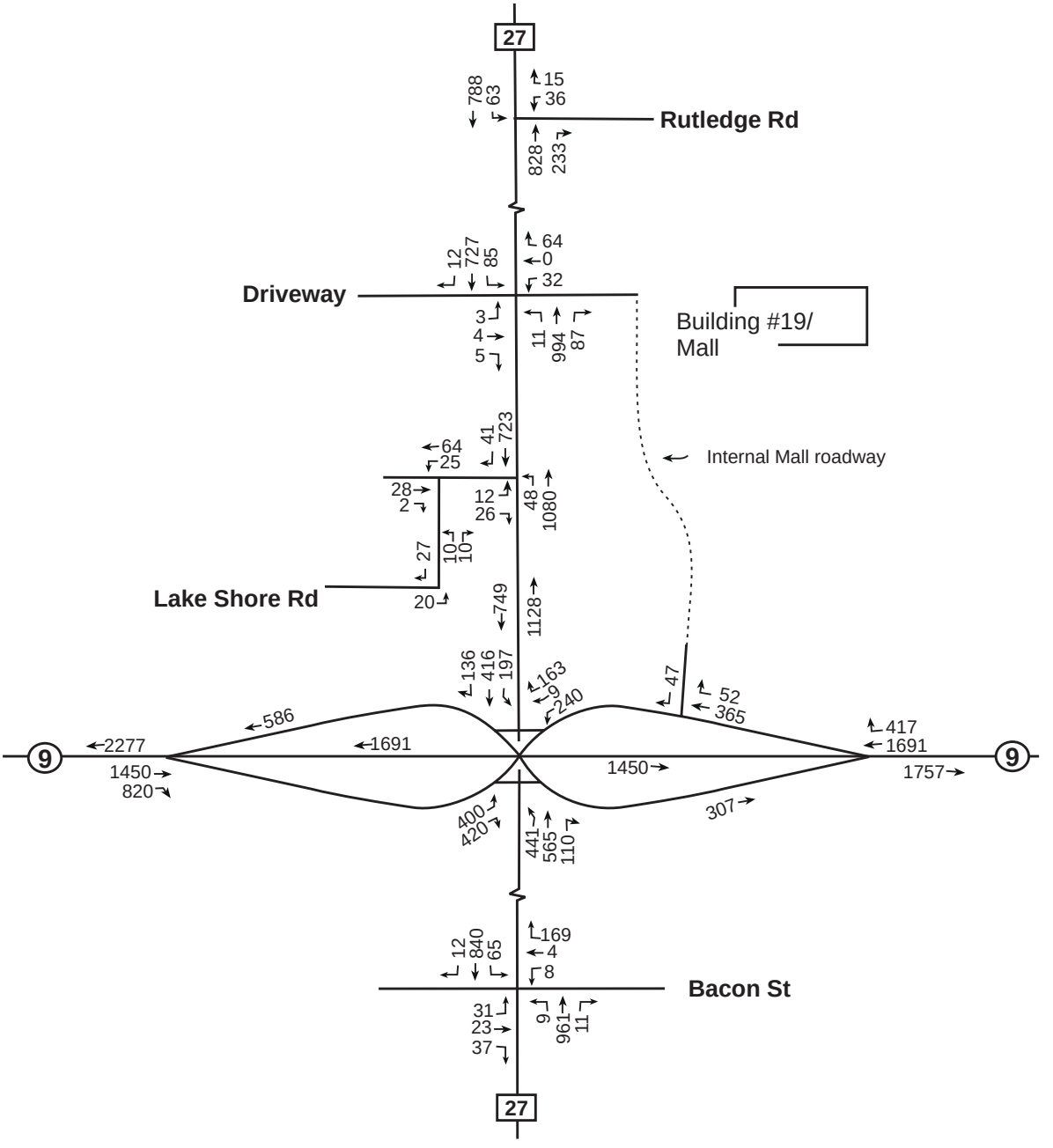

Figure 13
"Single-Point Diamond" Alternatives: AM Peak Hour Volumes

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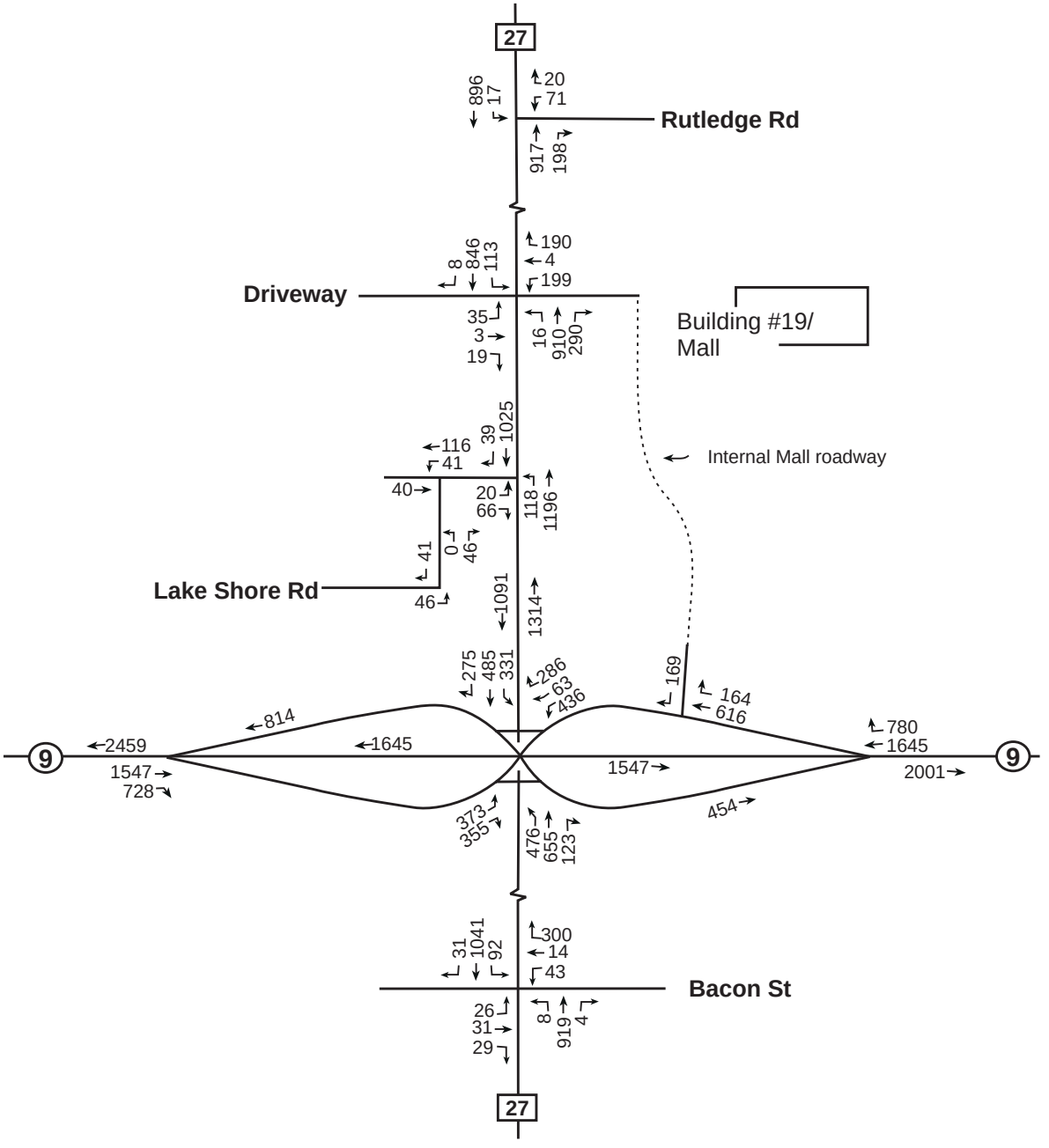

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Figure 14
"Single-Point Diamond" Alternatives: PM Peak Hour Volumes

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5. Analysis Results

The alternatives listed above were analyzed using Synchro to evaluate traffic operations, without consideration of environmental, land-taking, or other impacts at this early stage. The results of the capacity analyses are presented in **Tables 2** to **4**, and discussed below.

a) Of **Alternatives 1** through **3**, the best overall results are associated with **Alternative 2**, which includes a left-turn bay on North Main Street Southbound at Bacon Street, a 4-lane bridge over Route 9, and widening of North Main Street north of the interchange, to allow 2 northbound lanes between the interchange and Rutledge Road.

The primary benefits of this alternative are associated with relieving the existing queuing conditions, particularly at Bacon Street during the evening peak. Providing separate storage for southbound left turns is the single measure which would allow the greatest improvement over current conditions for the smallest level of investment or disruption. In addition, this alternative would relieve the complex weaving situation on the northbound approach to the North Main Street / Mall Driveway intersection, by creating additional room for northbound through traffic. It would provide 2 through northbound lanes in addition to the right-turn lane at this intersection, with the 2 through lanes becoming a single through, and a right-turn lane at Rutledge Road. The southbound side of North Main Street would remain in its current configuration north of the takeoff point for the Route 9 Westbound on-ramp; then, 2 through lanes would be carried all the way to the south side of the bridge over Route 9.

This alternative *does* involve adding capacity beyond the area of the existing interchange (between the interchange and Rutledge Road), and would require minor land-takings in order to accommodate the additional northbound lane.

b) **Alternative 1**, limited to providing a southbound left-turn bay at Bacon Street and a 4-lane bridge, yields substantial benefits in terms of reducing queues at this intersection, and reduced travel time overall, especially during the evening peak period. This is probably the first and most straightforward improvement which should be undertaken in the area, although it doesn't directly address interchange channelization issues.

c) **Alternative 3** does not appear to offer significant benefits, at least in terms of delays and queuing, and should be dropped. Its most problematic aspect is the high traffic demand it concentrates on the single Route 9 Westbound off-ramp, resulting in queues which extend back onto the highway. This queuing impact could be ameliorated to a large degree *if* the Mall driveway exiting onto this ramp were restricted to entering-only traffic (**Alternative 3-v)**; but it is still true that the costs of this alternative greatly exceed the potential benefits.

TABLE 2
Alternatives Analysis:
Summary of Signalized Intersection Results Using Synchro—
Existing and Alternatives 1-3

ALTERNATIVES	Inters'n: N. Main at:	Cycle Length	Inters'n LOS	Queues: Approaches Exceeding Capacity			
				ID	50-%ile	95-%ile	LOS
AM PEAK HOUR							
EXISTING	Bldg 19	81	A (7.9)	NBT	300	699#	B
	Bacon	84	A (9.4)	SBT	201	699#	B
Alternative 1	Bldg 19	80	B (12.3)	NBT	407	709#	B
	Bacon	80	A (9.4)	NBT	313	682#	B
Alternative 2	Bldg 19	55	A (5.7)	_____	_____	_____	(n/a)
	Bacon	75	A (7.4)	NBT	116	557#	A
Alternative 3	Bldg 19	100	A (3.2)	_____	_____	_____	(n/a)
	Bacon	100	A (9.7)	NBT	364	839#	B
	New Intersection	100	B (11.2)	_____	_____	_____	(n/a)
PM PEAK HOUR							
EXISTING	Bldg 19	81	C (24.2)	WBL/T	189~	361#	E
				NBT	427	74#	C
				SBL	19	84#	B
	Bacon	84	D (49.7)	WBT	92	249#	C
				SBT	792~	1038#	F
Alternative 1 --SB left-turn lane at Bacon, 4-lane bridge	Bldg 19	65	C (26.0)	WBL/T	149~	307#	E
				NBT	362~	621#	D
	Bacon	80	B (13.7)	WBT	91	240#	C
				NBT	251	478#	B
				SBT	318	750#	B
Alternative 2 **--Alt 1** *plus* widen N. Main to 2 lanes NB Route 9-to-Rutledge	Bldg 19	60	B (13.8)	WBL/T	119	250#	C
				SBT	207	481#	B
	Bacon	80	B (13.7)	WBT	91	240#	C
				NBT	251	478#	B
				SBT	318	750#	B
Alternative 3 --create signalized intersection, consolidate Route 9 WB off-bound moves	Bldg 19	90	A (9.8)	WBL/T	113	221#	D
				NBT	288	546#	A
	Bacon	90	B (14.4)	WBT	84	243#	C
				NBT	405	740#	B
	New Intersection	90	B (16.0)	_____	_____	_____	(n/a)

Table 2 (cont'd)

Alternative 3-v --same as **Alt 3**, but with no Mall exit on ramp	Bldg 19	80	C (24.3)	WBL / T NBT SBL SBT	180 421~ 20 345	347# 726# 83# 660#	E D B B
	Bacon	80	B (16.5)	WBT NBT SBT	75 405 62	221# 711# 375#	B C A
	New Intersection	80	B (14.1)	_____	_____	_____	(n / a)

† Calculated by Synchro, which uses the 1997 HCS methods to calculate Levels of Service and delays. These are different from the methods used by MassHighway, based on the 1994 Manual.

* Queue estimates are shown in feet, with assumed average vehicle length of 25 feet—thus, 225 feet represents 9 queued vehicles. Synchro calculates maximum queue lengths for traffic arrivals during (a) a typical cycle (50^{th} percentile) and (b) the 95^{th} percentile cycle (i.e., that with vehicle arrival rate greater than 95 percent of all cycles during the analysis period—only 5 percent of all signal cycles experience a greater arrival rate).

95^{th} percentile: volume exceeds limits of queuing formulas; value shown represents queue after 3 minutes, and is typically greater than queues actually experienced.

~ 50^{th} percentile: volume exceeds capacity on average; queue is theoretically infinite; value shown is sufficient to accommodate one cycle of traffic

_____ (n / a) volumes do not exceed capacity.

NOTE: In **Alternatives 1** and **2**, signals are *not* coordinated; the 3 signals of **Alternatives 3** and **3-v** *are* coordinated.

TABLE 3
Alternatives Analysis:
Summary of Signalized Intersection Results Using Synchro—
"Single-Point Diamond" Interchange Alternatives (PM Peak Hour only)

ALTERNATIVES	Inters'n: N. Main at:	Cycle Length	Inters'n LOS	Queues: Approaches Exceeding Capacity			
				ID	50-%ile	95-%ile	LOS
PM PEAK HOUR ONLY							
Alternative A --split phasing (i.e., each approach has its own exclusive phase)	Bldg 19	70	A (8.7)	WBL/T	82	156#	C
				NBT	184	220#	A
				SBL	15	57#	A
	1-Point Diamond A	70	F (110.7)	NBL	404~	498#	F
				NBT	350~	509#	F
				SBL	136	266#	C
				SBT	259~	430#	F
				SWL	156~	242#	F
				SWR	28	82#	D
				SWR2	0	103#	B
	Bacon	70	B (13.9)	WBT	81	221#	C
				NBT	253	619#	B
Alternative B --quad phasing (8-phase dual-ring controller), Synchro optimized	Bldg 19	100	A (8.6)	WBL/T	126	232#	D
	1-Point Diamond B	100	D (38.6)	NBL	316	502#	D
				NBT	343	673#	D
				SBL	225	401#	E
				SBT	245	521#	D
				SWL	150	245#	E
	Bacon	100	B (10.6)	WBT	116	266#	C
Alternative B-v --same as **Alt B**, but with with no Mall exit on ramp	Bldg 19	100	B (18.9)	WBT/L	227	405#	E
				NBT	310	783#	B
				SBL	29	125#	C
	1-Point Diamond B	100	D (35.1)	NBL	320	515#	E
				NBT	320	660#	C
				SBL	223	329#	D
				SBT	290	548#	D
				SWL	125	221#	E
	Bacon	100	B (10.1)	WBT	116	266#	C
Alternative C --quad phasing (8-phase dual-ring controller) with added lanes at Single-Point Diamond Interchange	Bldg 19	90	A (9.3)	WBL/T	113	221#	D
				NBT	79	409#	A
	1-Point Diamond C	90	C (23.4)	SBL	189	307#	C
				SWL	120	198#	D
	Bacon	90	B (13.2)	WBT	104	253#	C
				NBT	299	504#	B
				SBT	377	542#	B

Table 3 (cont'd)

Alternative D --same as **Alt B**, but with shorter cycle length	Bldg 19	80	A (9.7)	WBL/T	99	201#	C
	1-Point Diamond D	80	C (29.9)	NBL	195	304#	D
				NBT	290	400#	C
				SBL	131	303#	E
				SBT	217	379#	C
				NEL	82	137#	C
				NER2	0	113#	A
				SWL	101	184#	D
				SWR	28	82#	D
				SWR2	0	98#	B
	Bacon	80	B (13.5)	WBT	81	221#	C
				NBT	253	619#	B
				SBT	95	626#	A

† Calculated by Synchro, which uses the 1997 HCS methods to calculate Levels of Service and delays. These are different from the methods used by MassHighway, based on the 1994 Manual.

* Queue estimates are shown in feet, with assumed average vehicle length of 25 feet—thus, 225 feet represents 9 queued vehicles. Synchro calculates maximum queue lengths for traffic arrivals during (a) a typical cycle (50^{th} percentile) and (b) the 95^{th} percentile cycle (i.e., that with vehicle arrival rate greater than 95 percent of all cycles during the analysis period—only 5 percent of all signal cycles experience a greater arrival rate).

95^{th} percentile: volume exceeds limits of queuing formulas; value shown represents queue after 3 minutes, and is typically greater than queues actually experienced.

~ 50^{th} percentile: volume exceeds capacity on average; queue is theoretically infinite; value shown is sufficient to accommodate one cycle of traffic

_____ (n/a) approach volumes do not exceed capacity.

TABLE 4
System-Wide Summary

ALTERNATIVES	AM Peak Hour			PM Peak Hour		
	Total Travel Time, hrs	Queue Penalty	Perform-ance Index	Total Travel Time, hrs	Queue Penalty	Perform-ance Index
Primary Alternatives						
Existing	***91***	399	37.1	156	1078	109.7
Alternative 1	94	344	39.6	132	748	74.2
Alternative 2	95	***126***	***26.6***	***122***	***514***	***57.1***
Alternative 3	99	612	47.6	126	1483	94.9
Alternative 3-v	(not analyzed)			137	1763	116.7
"Single-Point Diamond" Alternatives						
Alternative A	163	675	115.9	234	1399	203.5
Alternative B	111	354	46.5	155	1094	101.4
Alternative B-v	(not analyzed)			159	1384	113.9
Alternative C	***108***	***184***	***40.1***	***141***	***603***	***74.2***
Alternative D	112	381	49.1	170	1127	122.1
Assuming Future Development at Executive Park Drive†						
Existing	96	472	42.0	(not analyzed)		
Alternative 2	98	120	26.9			
Alternative C	111	191	42.3			

KEY TO MEASURES:
Total Travel Time is an hourly summary of travel time network-wide.
Queuing Penalty is calculated by multiplying the percent of blocking time (i.e., the amount of time the upstream end of each link is blocked) by number of vehicles affected, and summing over network.
Performance Index is the measure based on which Synchro chooses the optimal cycle length, with the lowest value best; **Index** calculated as:

$$PI = \frac{\%\text{-ile signal delay (sec)} + 10^{*}(\text{no. vehicle stops}) + 100^{*}(\text{queue penalty})}{36}$$

(Source: *Synchro 4.0 User Guide*, TrafficWare, 1999)

Bold Italics indicates best values within each group.
† Only the best-performing alternatives from the two groups were analyzed, along with the existing configuration.

Note: "Single-point diamond" Alternatives include data for 3 signalized intersections; the "network totals" can't really be compared directly with **Alternatives 1** and **2**, because the latter alternatives include data for only 2 signalized intersections. Individual intersections *can* be compared across alternatives, however (see **Tables 2, 3** and **5**).

d) The "single-point diamond" alternatives as presented are not directly comparable with **Alternatives 1** and **2**, because they tally delays and queues for 3 signalized intersections, instead of just 2. Synchro essentially ignores unsignalized intersections, so that queues and delays associated with an intersection before and after signalization cannot be compared. The "single-point diamond" alternatives *are* more directly compared with **Alternative 3**, which similarly includes 3 signalized intersections.

That said, of the 4 "single-point diamond" alternatives (**Alternatives A** through **D**), only **Alternative C** results in overall area operation which appears to be close to the level of **Alternative 2** (see **Table 4**). **Alternative C** would create a major multi-lane intersection on a bridge deck above Route 9; this intersection would operate at Level of Service C and would minimize queuing at the signal, as noted in **Table 3** (shorter queues would still extend back through the unimproved sections of North Main Street).

This alternative would be likely to represent a greater degree of visual and environmental impact than other alternatives considered. In addition, it would be extremely expensive to build, in construction cost terms if not in land-taking. The general benefits listed above for this interchange type may make an alternative on this scale worth reconsidering at some time in the future, if it can be accommodated geometrically; and, in particular, if changing circumstances allowed it to be one component in a more comprehensive Route 9 or Route 27 improvement project. For the present, however, it is not a feasible or justifiable alternative.

6. Potential for Additional Development at Executive Park Drive

A new median break on Route 9 in the vicinity of the Apple Hill development will not be permitted by MassHighway, because of unacceptable safety and queuing impacts. Therefore, the only direct access to the businesses at Executive Park Drive from Route 9 will continue to be via right-turn-only entrance and exit from Route 9 Westbound. The preferred means of access for commuters approaching these businesses from Route 9 west of the Route 27 interchange is to continue eastward to the intersection with Oak Street, there making a U-turn and doubling back to Executive Park Drive. However, many such commuters reportedly use the Route 27 interchange as part of a circuitous "back-street"route to Executive Park, traveling through the residential neighborhoods of Rutledge Road, Wentworth Road and Wethersfield Road.

There is at least one remaining vacant building site adjacent to the Cognex property off Executive Park Drive. This site is likely to be proposed for office development, either for an expansion of one or more existing tenants or for a new tenant, in the near future. At this writing, no specific development proposal exists, to our knowledge; but it can be assumed that an additional office building would be on the order of the existing buildings on the site, viz., about 150,000-200,000 gross square feet in size. Depending on the type of office building contemplated, this level of addition would generate additional trips to Executive Park Drive, estimated as follows:

	150,000 GSF	200,000 GSF	Entering / Exiting Split
AM Pk Hr[3]	about 260	about 340	89% entering
PM Pk Hr[2]	about 260	about 330	85% exiting

Likewise, no information is available to us on the origins of traffic currently entering Executive Park Drive—i.e., the proportion of employees coming from the east vs. the west. If one assumes an even split between the two, and a preference for the Route 9 / Route 27 interchange among drivers coming from the west, then approximately 150 vehicles would be added to traffic on this route under the *higher* scenario during the AM Peak Hour. If the proportion from the west is closer to 70 percent, the number is over 200 vehicles.

It is worth noting that MassHighway is already planning a significant upgrade to the intersection of Route 9 at Oak Street. While alternatives currently under discussion are limited to at-grade intersections, and do not include grade separation, it is still reasonable to assume that the Oak Street intersection of the future will operate more efficiently than the present configuration; and that a higher percentage of drivers from the west will be willing to use Oak Street in the future as a direct turn-around on their route to Executive Park Drive. However, as a conservative assumption, it was assumed that half the added traffic from the west will continue to use the "back street" route via Rutledge Road.

The above assumptions are summarized as follows for the 200,000 GSF case:

Average AM Peak Hour trips generated:	= 340
About 89% are entering vehicles:	= 303
If about half are oriented toward the west:	= 151
If about 70% oriented toward the west:	= 212
If about half of these use Rutledge Road instead of Oak Street:	= 106

Although the PM Peak Hour would also experience increased volumes as a result of added development at Executive Park Drive, exiting traffic is not as critical, in terms of the diversion route, as is the AM Peak Hour. This is because traffic headed east in the evening from the site is likely to prefer using Route 9 WB-to-the Route 27 interchange to reverse direction on Route 9, and not the roundabout local-street route.

Figure 15 shows the impact of adding the incremental development traffic as defined above (i.e., 200,000 GSF development, with 70 percent coming from the west and half of these using Rutledge Road) to existing AM Peak Hour traffic volumes at the interchange and on Route 27. This possibility was also analyzed using the Synchro simulation model under existing conditions, as well as assuming **Alternatives 2** and **C** (the best-performing of the alternatives examined). The results of these analyses are summarized in **Tables 4** and **5**. Generally speaking, the added traffic results in a slight worsening of conditions under any

[3] Based on Institute of Transportation Engineers, *Trip Generation*, 6th Edition, intermediate values between LU 710 (General Office Building) and LU 715 (Single-tenant Office Building), generated using equations as given for trips as a function of 1,000 gross square feet of area.

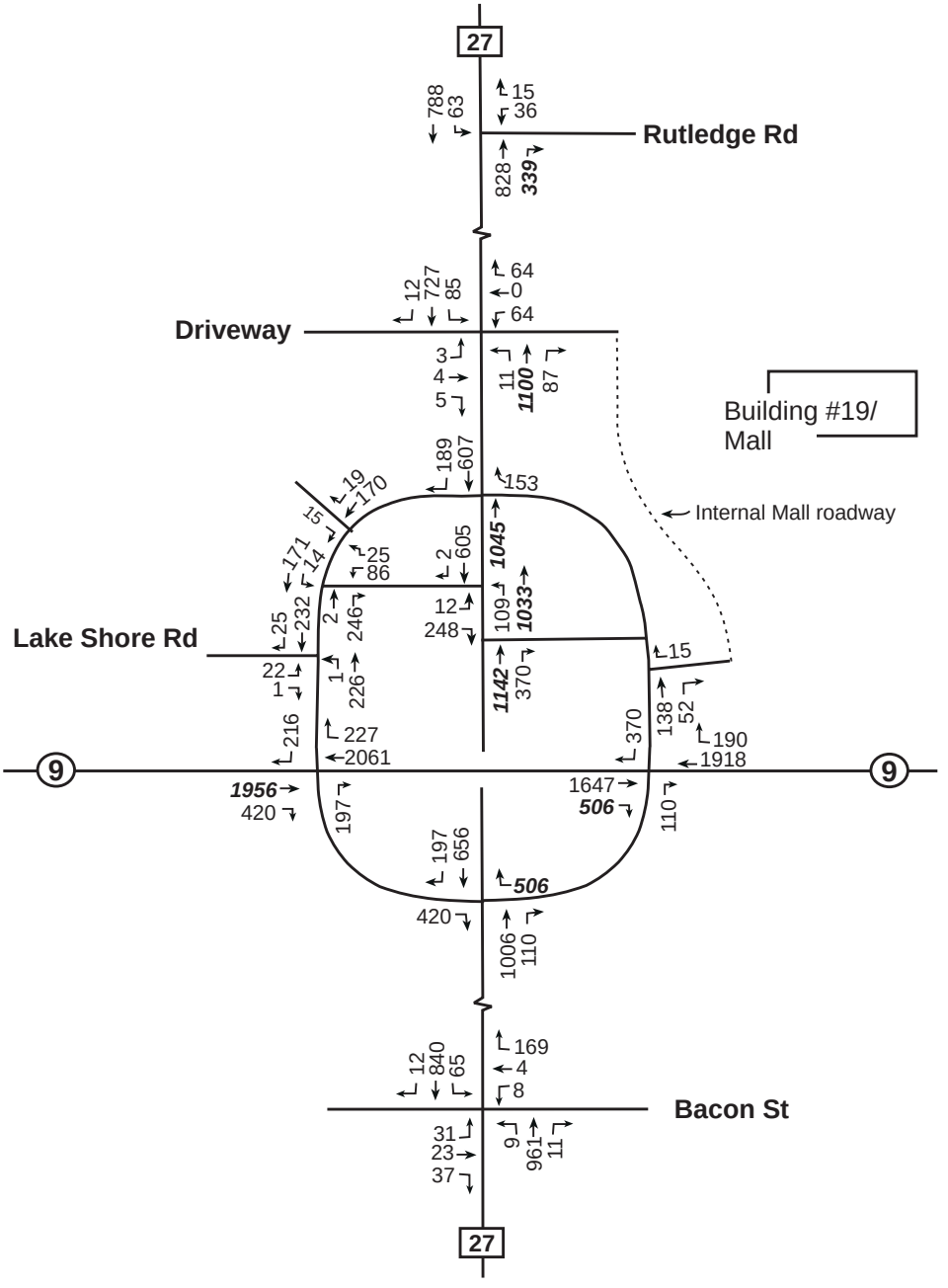
of the alternatives. Those alternatives which involve adding capacity to Route 27 perform better under the added-traffic scenario than alternatives which maintain the existing lane configurations. However, the AM Peak Hour, when the added traffic is most at issue, is less intense, with fewer queuing and delay problems, than the PM Peak Hour, and therefore is not as critical in determining a desirable option for interchange improvement.

However, the added morning traffic *is* likely to be an issue for the residents of the Wentworth Street and Wethersfield Road neighborhoods. The Town of Natick is interested in exploring the potential for creating an alternative, "back-door" entrance into the Executive Park, using Route 27, Rutledge Road, and Rutledge Lane. A new Executive Park entrance at the end of Rutledge Lane would be available to exiting as well as entering traffic; and would in all likelihood become a major access point for Cognex employees and other current tenants / occupiers of the site, as well as for any new office buildings developed on currently-vacant parcels. Depending on resulting traffic diversions, a traffic signal might be needed at the intersection of North Main Street and Rutledge Road. We understand that, because of topographic constraints, the "back-door"concept is contingent upon a favorable vote at Natick Town Meeting on the question of building a new Wilson School adjacent to the site of the existing school building. The funding and advancement of such a "back-door" concept would be a Town of Natick initiative.

If provision of an additional entrance to the Executive Park proves infeasible, newly-generated traffic at that location will continue to use the existing circulation pattern. Ideally, added development at Executive Park Drive would not be permitted to occur at all until a redesigned Route 9 / Oak Street intersection is available for the use of U-turning commuters from Route 9. But it is likely that development proposals will be advanced before Oak Street improvements can be completed. In the interim, residents of Wentworth Street and Wethersfield Road may wish to investigate the application of traffic-calming strategies such as one-way street designation and speed humps to discourage commuter traffic from using these streets as a bypass route to the Executive Park.

7. Conclusions and Recommendations

1) The interchange of Route 9 at Route 27 currently handles high volumes of traffic under constrained conditions, complicated by the non-standard geometry of the ramps. Improvements to the interchange itself, either to add capacity or simply to eliminate / simplify conflicting movements, can be investigated. However, areas to the north and south of the interchange are intensely developed, with businesses and residences located very close to the roadway. Consequently, little opportunity exists at present to widen or add capacity to Route 27 beyond the immediate vicinity of the interchange (except at isolated locations), even if local residents and businesses were in favor of such capacity additions.



Affected moves include +106 added vehicles generated by incremental development (shown in ***bold italics).***

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Figure 15
AM Peak Hour Volumes with Added Development at Executive Park Drive

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TABLE 5
Alternatives Analysis:
Summary of Signalized Intersection Results Using Synchro—
Including Added Traffic at Executive Park Drive (EPD)

ALTERNATIVES	Inters'n: N. Main at:	Cycle Length	Inters'n LOS	Queues: Approaches Exceeding Capacity			
				ID	50-%ile	95-%ile	LOS
AM PEAK HOUR ONLY							
EXISTING with future development at EPD	Bldg 19	81	B (11.6)	NBT	385	823#	B
	Bacon	84	A (9.4)	SBT	201	699#	B
Alternative 2 (added capacity) with future development at EPD	Bldg 19	60	A (5.6)	_____	_____	_____	(n/a)
	Bacon	75	A (7.4)	NBT	116	557#	A
Alternative C (single-point diamond) with future development at EPD	Bldg 19	70	A (8.2)	NBT	105	753#	B
	1-Point Diamond C	70	B (18.0)	SBL	83	145#	C
	Bacon	70	A (6.8)	NBT	166	618#	A

† Calculated by Synchro, which uses the 1997 HCS methods to calculate Levels of Service and delays. These are different from the methods used by MassHighway, based on the 1994 Manual.

* Queue estimates are shown in feet, with assumed average vehicle length of 25 feet—thus, 225 feet represents 9 queued vehicles. Synchro calculates maximum queue lengths for traffic arrivals during (a) a typical cycle (50th percentile) and (b) the 95th percentile cycle (i.e., that with vehicle arrival rate greater than 95 percent of all cycles during the analysis period—only 5 percent of all signal cycles experience a greater arrival rate).

# indicates 95th # 95th percentile: volume exceeds limits of queuing formulas; value shown represents queue after 3 minutes, and is typically greater than queues actually experienced.

~ 50th percentile: volume exceeds capacity on average; queue is theoretically infinite; value shown is sufficient to accommodate one cycle of traffic

_____ (n/a) approach volumes do not exceed capacity.

2) The most obvious problems at the interchange are associated with long vehicle queues and associated delays, particularly queues extending northward along North Main Street from the Bacon Street signal during the PM Peak Hour; but also across the bridge over Route 9 in both directions. These queues interfere with operations from the Route 9 ramps, and can cause vehicle back-ups on to the Route 9 travel lanes.[4]

It is unlikely that queues can be eliminated entirely. However, **Alternative 2** includes strategies for greatly reducing the level of queuing in the vicinity of the interchange, and is the preferred alternative resulting from the analysis.

- Widening the southbound approach of North Main Street at Bacon to provide a short left-turn bay in front of the White Hen Pantry would greatly benefit operations at this traffic signal in the evening peak hour. Such a left-turn bay could be narrower than a full-width lane, and need not accommodate more than 2 or 3 left-turn vehicles at a time to be effective. **This is the single most beneficial of the improvements options investigated**, in terms of benefits compared with costs.

  We recommend that this strategy be advanced to determine how much, if any, sidewalk encroachment would be required. If there is *not* sufficient width to allow for striping a formal left-turn bay, the available lane area should be widened as far as possible to allow through traffic to bypass at least a single left-turn vehicle. (Note: provision of a southbound left-turn lane on North Main Street at Bacon is a strategy which can be implemented independently of, **or** in conjunction with, improvements to the bridge over Route 9).

- The replacement bridge should be designed with a minimum travel width of 4 lanes. This, too, will provide significant relief to vehicle queues, although it will not eliminate peak-period queues; and it will provide opportunities for improved channelization of turns, particularly on the north side of the bridge and particularly if minor widening can be included just north of the interchange.

- Minor widening of Route 27 immediately north of the interchange, as described in **Alternative 2**, increases the benefit of a wider bridge without encroaching on the more residential portions of North Main Street. In particular, providing an additional northbound lane to Rutledge Road reduces the merge / weave conflict for traffic from the Route 9 Westbound off-ramp, a significant benefit which is only indirectly reflected in the Synchro analysis results presented here.

3) In the event that serious objections arise to the notion of widening Route 27 north of the interchange as discussed, **Alternative 1**, which includes a wider bridge and a southbound left-turn bay on North Main at Bacon, is the recommended alternative.

[4] The Natick Police report that accidents are also an issue at this location, most notably rear-end collisions. We would have liked to verify this, and to determine the circumstances and precise locations of such collisions; but were not given access to police accident records.

It incorporates most of the benefits of **Alternative 2** without incurring the costs and disruption of even minor roadway widening.

4) The existing interchange design should be retained in lieu of combining ramp movements, as investigated in **Alternative 3**. The benefit of combining all westbound exiting movements onto a single ramp could be a reduction in rear-end collisions associated with ramp-related weaving operations on Route 9. However, the ramp volumes are too high to make this a desirable alternative unless the entire interchange is to be redesigned.

5) In the long term, replacement of the existing interchange with a "single-point diamond"-type design (**Alternatives A** through **D**) might yield operational benefits at this location beyond those measurable by the Synchro analysis: (a) by simplifying the presently-complicated access to Lake Shore Road, nearby businesses, and the Building 19 1/5-Super Stop & Shop Mall, and (b) by providing longer, more gently-tapered on- and off-ramps to Route 9. For the present, however, it does not represent a feasible or justifiable alternative as an isolated improvement. The planned bridge reconstruction should proceed, preferably with a 4 travel-lane bridge.

6) To the extent possible, improved pedestrian connections should be provided along North Main Street, including sidewalks on the east side (i.e., same side as the Mall), and sidewalks, curbing and crosswalks at the intersection of Rutledge Road with North Main Street. A pedestrian-actuated signal might also be considered at this intersection. Alternatively, signs directing motorists on North Main Street to "Yield to Pedestrians in Cross-Walk" may provide improved pedestrian safety at Rutledge Road without creating long and frequent vehicle backups in both directions here.

7) The generation of additional traffic entering Executive Park Drive in the morning peak period will mean that greater numbers of vehicles will use the circuitous "short-cut," via Rutledge Road, to avoid making a U-turn at the Route 9/Oak Street intersection. Given a likely scale of office development for this site (i.e., around 200 thousand square feet), the additional traffic will represent a noticeable increase, especially to neighborhood residents; but it should not be enough to cause Levels of Service to deteriorate significantly at the interchange or the major intersections on Route 27. Several opportunities exist to help mitigate impacts on the neighborhood:

- The Town of Natick is, on its own initiative, currently investigating a concept which would create a "back-door" access point, via Rutledge Lane and Rutledge Road, for traffic entering and leaving the Executive Park. If the Town succeeds in creating such a "back-door", the new access point would eliminate the need for the circuitous commuter route through local neighborhood.

- In addition, it is likely that progress will be made on upgrading the Route 9/Oak Street intersection over the next few years, to the point where it

represents a less onerous route choice for Executive Park commuters from the west than it does at present.

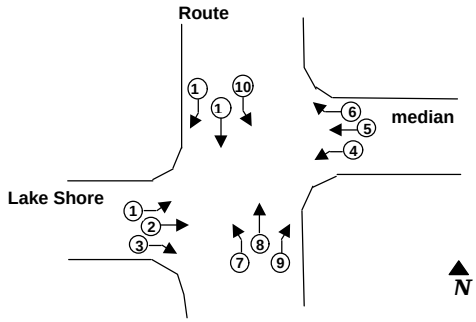
APPENDIX A: Traffic Data

1. Traffic Counts
2. Intersection Geometry / Signal Timing
3. Measured Intersection Queues

Street:	Lakeshore Rd			Median Break			Rt 9 NB off r			Rt 27 to Rt 9 WB			
Direction:	EB			WB			NB			SB			
Movemen	L	S	R	L	S	R	L	S	R	L	S	R	Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15	0	3	1	9	0	2	0	0	47	1	27	0	90
7:15-7:30	0	1	0	14	2	2	0	1	39	0	31	0	90
7:30-7:45	0	6	1	5	3	2	0	0	46	1	41	0	105
7:45-8:00	1	6	0	12	2	2	0	0	32	0	38	1	94
8:00-8:15	0	5	1	9	2	2	0	0	40	2	42	0	103
8:15-8:30	0	4	0	21	3	3	0	0	52	2	45	3	133
8:30-8:45	0	2	0	11	1	10	1	1	64	3	27	2	122
8:45-9:00	1	3	0	18	2	0	0	1	69	2	32	0	128
9:00-9:15													0
9:15-9:30													0
Col.Total	2	30	3	99	15	23	1	3	389	11	283	6	865
AM PEAK													
8:00-9:00	1	14	1	59	8	15	1	2	225	9	146	5	486
HOUR										PHF =	0.91		

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15	0	9	0	19	4	8	1	4	97	13	91	4	250
4:15-4:30	0	7	3	23	1	8	0	3	73	11	60	6	195
4:30-4:45	0	3	1	29	4	8	0	5	83	10	66	4	213
4:45-5:00	0	6	2	27	10	5	0	5	80	18	89	15	257
5:00-5:15	1	9	1	20	5	4	1	3	52	13	70	14	193
5:15-5:30	1	3	0	26	1	3	3	1	88	9	49	2	186
5:30-5:45	2	8	0	22	6	1	3	2	82	7	89	8	230
5:45-6:00	0	3	0	32	10	4	0	1	70	13	66	2	201
6:00-6:15													0
6:15-6:30													0
Col.Total	4	48	7	198	41	41	8	24	625	94	580	55	1725
PM PEAK													
4:00-5:00	0	25	6	98	19	29	1	17	333	52	306	29	915
HOUR										PHF =	0.89		

SKETCH



Date: June 9, 1999
Day: Wednesday
Weather: Hot
By: LS
City: Natick, MA
Location: Route 9/27 Interchange--
north side

TRAFFIC COUNT | Figure

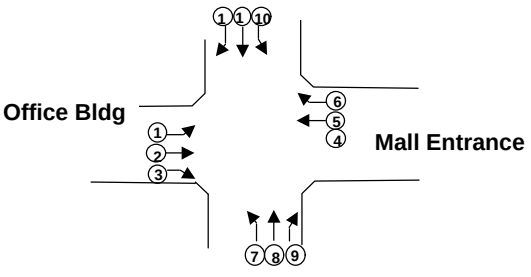
\MetroWest\P_Rt27Natick\Analysis\Counts\CTPS-TMs\na1.xls

C T P S

Street:	Office Park			Mall Entrance			Route 27			Route 27			
Direction:	EB			WB			NB			SB			
Movement	L	S	R	L	S	R	L	S	R	L	S	R	Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15	1	0	1	15	0	8	2	220	17	10	138	1	413
7:15-7:30	0	0	0	21	0	8	1	215	14	10	140	4	413
7:30-7:45	0	0	0	16	0	8	3	308	13	19	176	2	545
7:45-8:00	2	0	1	16	0	19	2	267	22	14	167	1	511
8:00-8:15	1	1	0	18	0	15	1	232	14	23	153	2	460
8:15-8:30	0	1	2	12	0	19	1	253	21	21	184	5	519
8:30-8:45	2	0	2	22	0	14	2	243	22	21	193	3	524
8:45-9:00	0	2	1	12	0	16	7	249	28	20	197	2	534
9:00-9:15													0
9:15-9:30													0
Col.Total	6	4	7	132	0	107	19	1987	151	138	1348	20	3919
AM PEAK 8:00-9:00 HOUR	3	4	5	64	0	64	11	977	85	85 PHF =	727 0.93	12	2037

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15	6	1	3	84	1	58	5	251	74	43	182	4	712
4:15-4:30	8	0	8	86	0	51	4	271	59	31	206	2	726
4:30-4:45	12	1	5	101	1	47	4	268	81	50	232	1	803
4:45-5:00	9	1	3	78	2	59	3	263	66	39	226	1	750
5:00-5:15	14	3	6	79	0	49	3	238	41	17	163	2	615
5:15-5:30	6	0	1	78	1	55	1	290	54	39	222	6	753
5:30-5:45	4	0	4	84	1	60	5	288	61	43	215	4	769
5:45-6:00	4	0	4	74	2	45	2	280	54	40	190	6	701
6:00-6:15													0
6:15-6:30													0
Col.Total	63	6	34	664	8	424	27	2149	490	302	1636	26	5829
PM PEAK 4:00-5:00 HOUR	35	3	19	349	4	215	16	1053	280	163 PHF =	846 0.93	8	2991

SKETCH



Date: June 8, 1999
Day: Tuesday
Weather: Hot
By: LS
City: Natick, MA
Location: Route 27 at Mall Entrance (signalized)

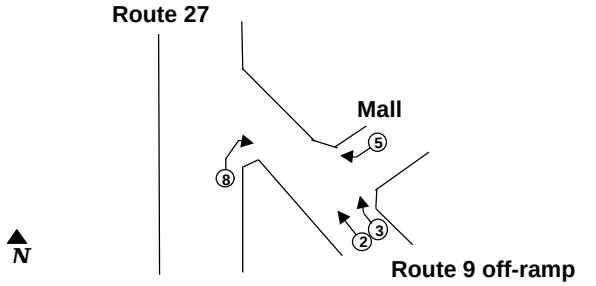
TRAFFIC COUN | Figure

C T P S

Street:		WB off-ramp			Mall D'way			Rt 27 NB					
Direction:		NB			WB			NB					
Movement:		S	R		R			R					Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15		27	0		3			48					78
7:15-7:30		23	7		2			67					99
7:30-7:45		24	6		6			67					103
7:45-8:00		37	15		3			107					162
8:00-8:15		25	8		6			86					125
8:15-8:30		31	15		1			81					128
8:30-8:45		35	14		0			96					145
8:45-9:00		41	22		1			85					149
9:00-9:15													0
9:15-9:30													0
Col.Total	0	243	87	0	22	0	0	637	0	0	0	0	989
AM PEAK													
7:45-8:45	0	128	52	0	10	0	0	370	0	0	0	0	560
HOUR									PHF =	0.86			

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15		47	44		6			97					194
4:15-4:30		43	42		11			84					180
4:30-4:45		32	43		8			113					196
4:45-5:00		53	37		9			116					215
5:00-5:15		59	37		6			106					208
5:15-5:30		39	47		3			112					201
5:30-5:45		53	41		12			100					206
5:45-6:00		51	39		8			119					217
6:00-6:15													0
6:15-6:30													0
Col.Total	0	377	330	0	63	0	0	847	0	0	0	0	1617
PM PEAK													
5:00-6:00	0	202	164	0	29	0	0	437	0	0	0	0	832
HOUR									PHF =	0.96			

SKETCH



Date: June 8, 1999
Day: Tuesday
Weather: Hot
By: KS
City: Natick, MA
Location: Route 27 and WB off-ramp (with Mall entrance)

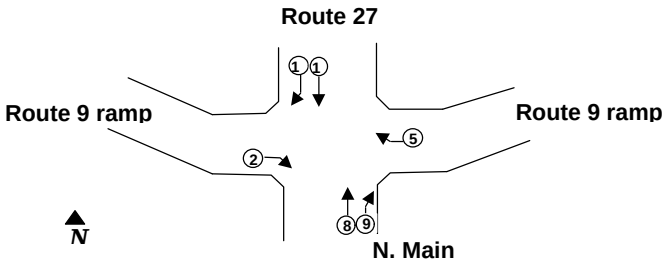
TRAFFIC COUN | Figure

/metrowest/rt27/analysis/counts/na3.xls

Street:		EB off-ramp			EB off-ramp 2			Route 27			Route 27		
Direction:		EB			WB			NB			SB		
Movement:		R			R			S	R		S	R	Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15		96			58			207	31		131	36	559
7:15-7:30		85			33			214	25		123	33	513
7:30-7:45		116			100			251	21		144	42	674
7:45-8:00		157			117			259	26		132	57	748
8:00-8:15		100			104			240	14		155	51	664
8:15-8:30		97			114			254	29		150	47	691
8:30-8:45		74			88			227	28		144	50	611
8:45-9:00		72			110			272	32		141	59	686
9:00-9:15													0
9:15-9:30													0
Col.Total	0	797	0	0	724	0	0	1924	206	0	1120	375	5146
AM PEAK													
7:30-8:30	0	470	0	0	435	0	0	1004	90	0	581	197	2777
HOUR										PHF =	0.93		

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15		88			94			240	31		154	88	695
4:15-4:30		87			84			264	26		184	118	763
4:30-4:45		117			126			283	27		237	117	907
4:45-5:00		93			110			259	20		216	91	789
5:00-5:15		97			107			256	26		252	116	854
5:15-5:30		118			103			253	30		251	62	817
5:30-5:45		136			132			250	23		186	60	787
5:45-6:00		116			130			281	18		254	87	886
6:00-6:15													0
6:15-6:30													0
Col.Total	0	852	0	0	886	0	0	2086	201	0	1734	739	6498
PM PEAK													
4:30-5:30	0	425	0	0	446	0	0	1051	103	0	956	386	3367
HOUR										PHF =	0.93		

SKETCH



Date: June 8-9, 1999
Day: Tuesday-Wednesday
Weather: Hot
By: SWG
City: Natick, MA
Location: Route 9/27 Interchange--
south side

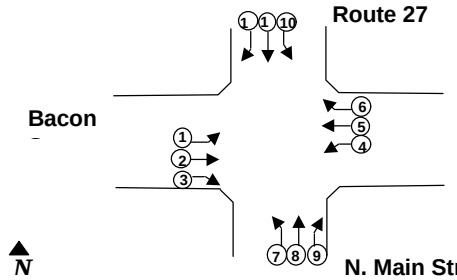
TRAFFIC COUN | Figure

/metrowest/rt27/analysis/counts/na4.xls

Street:	Bacon St			Bacon St			North Main St			North Main St			
Direction:	EB			WB			NB			SB			
Movement	L	S	R	L	S	R	L	S	R	L	SB	R	Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15	12	5	16	2	0	45	2	198	1	7	206	1	495
7:15-7:30	16	4	12	1	2	38	0	241	2	13	123	0	452
7:30-7:45	7	7	5	3	3	44	0	239	5	20	168	4	505
7:45-8:00	8	6	13	1	1	44	4	240	4	17	238	5	581
8:00-8:15	14	3	9	4	1	32	2	242	3	18	172	4	504
8:15-8:30	15	7	8	2	1	58	1	239	0	18	195	0	544
8:30-8:45	14	7	7	1	1	49	2	250	4	12	165	3	515
8:45-9:00	3	5	15	4	1	41	5	238	4	19	180	3	518
9:00-9:15													0
9:15-9:30													0
Col.Total	89	44	85	18	10	351	16	1887	23	124	1447	20	4114
AM PEAK													
7:45-8:45	51	23	37	8	4	183	9	971	11	65	770	12	2144
HOUR										PHF =	0.92		

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15	17	1	13	8	4	29	7	269	2	11	215	5	581
4:15-4:30	16	3	7	7	1	41	1	215	6	23	197	1	518
4:30-4:45	11	2	7	5	2	43	1	249	2	18	233	5	578
4:45-5:00	8	2	9	9	2	72	5	216	1	19	232	9	584
5:00-5:15	12	8	2	15	7	94	1	280	1	7	207	2	636
5:15-5:30	4	6	12	9	4	73	1	238	0	19	240	5	611
5:30-5:45	4	9	10	12	2	57	2	200	1	16	263	6	582
5:45-6:00	8	8	5	7	1	90	4	201	2	20	261	8	615
6:00-6:15													0
6:15-6:30													0
Col.Total	80	39	65	72	23	499	22	1868	15	133	1848	41	4705
PM PEAK													
5:00-6:00	28	31	29	43	14	314	8	919	4	62	971	21	2444
HOUR										PHF =	0.96		

SKETCH



Date: September 14, 1999
Day: Tuesday
Weather: Fair, Dry
By: LS/CS
City: Natick, MA
Location: North Main St. (Rt 27) at Bacon St.

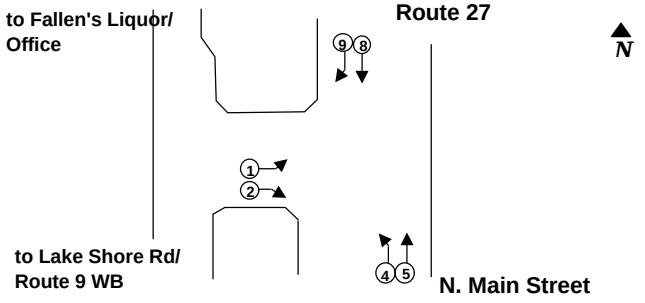
TRAFFIC COUNT | Figure

/metrowest/rt27/analysis/counts/na5.xls

Street:	Crossover			North Main St				North Main St					
Direction:	EB			NB				SB					
Movement	L	R		L	S			S	R				Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15	1	55		26	211			149	1				443
7:15-7:30	2	43		16	229			139	0				429
7:30-7:45	1	44		14	270			134	0				463
7:45-8:00	1	70		27	250			172	0				520
8:00-8:15	2	65		22	245			133	0				467
8:15-8:30	2	77		31	264			162	1				537
8:30-8:45	2	93		29	201			140	1				466
8:45-9:00	5	90		41	204			167	1				508
9:00-9:15													0
9:15-9:30													0
Col.Total	16	537	0	206	1874	0	0	1196	4	0	0	0	3833
AM PEAK													
7:45-8:45	7	305	0	109	960	0	0	607	2	0	0	0	1990
HOUR										PHF =	0.93		

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15	11	107		40	198			170	0				526
4:15-4:30	9	94		33	185			167	0				488
4:30-4:45	4	117		36	219			180	0				556
4:45-5:00	9	94		42	212			197	3				557
5:00-5:15	4	146		55	254			193	1				653
5:15-5:30	3	162		49	234			163	0				611
5:30-5:45	6	150		47	214			195	1				613
5:45-6:00	2	124		30	219			202	2				579
6:00-6:15													0
6:15-6:30													0
Col.Total	48	994	0	332	1735	0	0	1467	7	0	0	0	4583
PM PEAK													
5:00-6:00	15	582	0	181	921	0	0	753	4	0	0	0	2456
HOUR										PHF =	0.94		

SKETCH



Date: September 14, 1999
Day: Tuesday
Weather: Fair, Dry
By: SWG
City: Natick, MA
Location: Crossover from North Main St. to Route 27, north of Route 9

TRAFFIC COUNT | Figure

/metrowest/rt27/analysis/counts/na6.xls

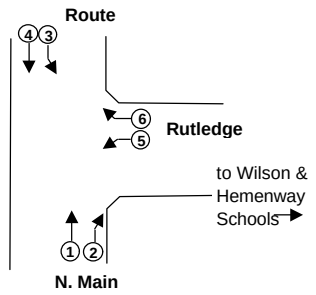
Street:	Rt 27		Rt 27		Rutledge Rd								
Direction:	NB		SB		WB								
Movement	T	R	L	T	L	R							Row
Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
6:30-6:45													0
6:45-7:00													0
7:00-7:15	145	22	2	120	8	2							299
7:15-7:30	192	68	14	133	15	1							423
7:30-7:45	224	85	21	148	17	14							509
7:45-8:00	156	71	9	161	24	9							430
8:00-8:15	211	80	13	192	9	5							510
8:15-8:30	202	60	19	199	8	4							492
8:30-8:45	209	50	16	185	8	1							469
8:45-9:00	191	43	15	206	11	7							473
9:00-9:15													0
9:15-9:30													0
Col.Total	1530	479	109	1344	100	43	0	0	0	0	0	0	3605
AM PEAK 8:00-9:00	813	233	63	782	36	17	0	0	0	0	0	0	1944
HOUR									PHF =	0.95			

Column #	1	2	3	4	5	6	7	8	9	10	11	12	Totals
3:30-3:45													0
3:45-4:00													0
4:00-4:15	209	32	5	176	7	7							436
4:15-4:30	188	38	6	181	12	2							427
4:30-4:45	203	37	8	169	23	7							447
4:45-5:00	196	42	4	192	10	8							452
5:00-5:15	247	44	3	176	9	4							483
5:15-5:30	226	56	8	166	15	5							476
5:30-5:45	228	42	2	166	7	3							448
5:45-6:00	224	49	8	136	24	9							450
6:00-6:15													0
6:15-6:30													0
Col.Total	1721	340	44	1362	107	45	0	0	0	0	0	0	3619
PM PEAK 4:45-5:45	897	184	17	700	41	20	0	0	0	0	0	0	1859
HOUR									PHF =	0.96			

SKETCH

cars in school lots, AM:

	6:50
9:10	
Wilson	2
70	



N

Date: November 17, 1999
Day: Wednesday
Weather: Cold, Dry
By: MPM
City: Natick, MA
Location: North Main St. (Rt 27) at Rutledge Road (note: most hectic time is school arrival time (7:30-7:45), 'tho not within "peak hour")

TRAFFIC COUNT | Figure

/metrowest/rt27/analysis/counts/na7.xls

Year/Source: **1999, done by MassHighway by request**

town_name NATICK

route 9

street

location description Route 9 East of Route 27

direction	1	1	1	1		3	3	3	3		
station_number											
year	99	99	99	99		99	99	99	99		
month	10	10	10	10		10	10	10	10		
day	5	6	7	8	TOTAL	5	6	7	8	TOTAL	
day of week											
Hour ending??											
1am		146	157	168	157		167	178	161	169	9
2am		68	75	73	72		95	106	105	102	2
3am		41	44	41	42		47	57	61	55	5
4am		51	39	42	44		38	43	52	44	4
5am		99	100	119	106		62	38	55	52	2
6am		434	441	396	424		223	238	220	227	7
7am		1584	1594	1431	1536		820	842	805	822	2
8am		2318	2306	2187	2270		1578	1524	1604	1569	9
9am		2311	2252	2202	2255		2140	2089	2086	2105	5
10am		1846	1758	1804	1803		1679	1657	1760	1699	9
11am		1618	1568		1593		1674	1715		1695	5
12pm		1840	1776		1808		1871	1937		1904	4
1pm		2016	1998		2007		2268	2251		2260	0
2pm	1892	1923	1964		1926	2047	2045	2033		2042	2
3pm	1906	1886	1981		1924	1907	2078	1956		1980	0
4pm	1878	1953	2046		1959	2165	2319	2237		2240	0
5pm	2014	2054	1929		1999	2443	2377	2347		2389	9
6pm	2235	2330	2261		2275	2495	2278	2334		2369	9
7pm	1921	1898	1869		1896	2319	2431	2360		2370	0
8pm	1384	1442	1433		1420	1810	1829	1736		1792	2
9pm	1130	1169	1205		1168	1138	1204	1207		1183	3
10pm	905	951	956		937	978	976	966		973	3
11pm	555	544	610		570	571	605	686		621	1
12am	254	291	330		292	332	379	393		368	8
Totals	16074	30813	30692	8463	30483	18205	31183	30930	6909	31030	

Two-way sum = 61513

MassHighway-adjusted = ((.92)(.97) 54,900

Year/Source: **1999, done by MassHighway by request**

town_na	NATICK										
route	27										
street											
location	Route 27 North of Pleasant St										
directio		0	0	0	0		2	2	2	2	
station_											
year		99	99	99	99		99	99	99	99	
month		10	10	10	10		10	10	10	10	
day		5	6	7	8	TOTAL	5	6	7	8	TOTAL
day of											
Hour											
1am			53	38	32	41		58	67	91	72
2am			30	20	25	25		34	30	51	38
3am			12	14	14	13		24	24	25	24
4am			26	19	25	23		14	11	17	14
5am			45	43	42	43		27	24	33	28
6am			130	136	138	135		101	99	98	99
7am			558	593	538	563		549	522	444	505
8am			1050	1025	1031	1035		940	983	944	956
9am			1173	1211	1145	1176		830	1034	868	911
10am			835	903	900	879		700	719	707	709
11am			823	839		831		677	718		698
12pm			956	1000		978		789	808		799
1pm			926	963		945		981	925		953
2pm		935	868	922		908	882	890	945		906
3pm		890	918	965		924	956	990	1008		985
4pm		1087	1144	1219		1150	1018	1062	1046		1042
5pm		1191	1160	1288		1213	1090	1138	1088		1105
6pm		1266	1298	1264		1276	1118	1146	1133		1132
7pm		1017	988	1005		1003	1159	1107	1156		1141
8pm		674	708	691		691	833	859	863		852
9pm		425	501	462		463	581	574	577		577
10pm		336	338	333		336	454	536	511		500
11pm		231	179	205		205	285	258	329		291
12am		108	93	137		113	147	164	159		157
Totals		8160	14812	15295	3890	14969	8523	14448	14779	3278	14494

Two-way sum = 29463

MassHighway-adjusted = ((.92)(.97)) 26,300

Year/Source: **1999, done by MassHighway by request**

town_name	NATICK									
route	27									
street location	Route 27 South of Rutledge Rd									
direction	0	0	0	0		2	2	2	2	
station_number										
year	99	99	99	99		99	99	99	99	
month	10	10	10	10		10	10	10	10	
day	5	6	7	8	TOTAL	5	6	7	8	TOTAL
day of week										
Hour ending??										
1am		51	43	34	43		28	30	38	32
2am		14	11	17	14		15	14	21	17
3am		13	14	9	12		14	8	11	11
4am		7	6	9	7		6	11	7	8
5am		31	30	39	33		15	19	20	18
6am		77	96	98	90		77	85	66	76
7am		486	471	440	466		388	365	320	358
8am		1027	1019	1033	1026		712	790	780	761
9am		1069	1084	1057	1070		821	941	830	864
10am		820	751	787	786		735	806	748	763
11am		707	676		692		643	655		649
12pm		792	804		798		685	700		693
1pm		860	924		892		703	749		726
2pm	905	908	908		907	814	779	780		791
3pm	879	907	897		894	811	875	867		851
4pm	966	943	1064		991	904	920	945		923
5pm	1068	1041	1121		1077	957	916	1057		977
6pm	1193	1206	1179		1193	1055	1175	1157		1129
7pm	949	947	965		954	1001	944	1117		1021
8pm	666	694	629		663	576	605	627		603
9pm	480	521	485		495	375	350	343		356
10pm	381	352	343		359	243	290	265		266
11pm	232	182	203		206	150	152	177		160
12am	84	87	117		96	77	85	89		84
Totals	7803	13742	13840	3523	13764	6963	11933	12597	2841	12137

Two-way sum = 25901

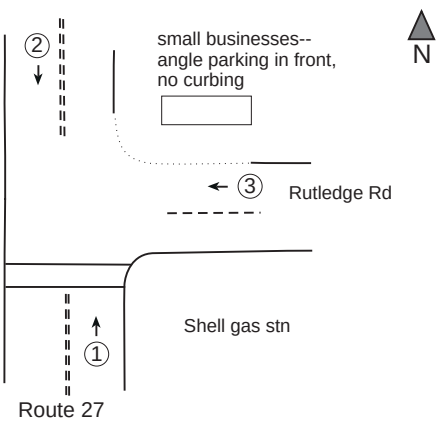
MassHighway-adjusted = ((.92)(.97)) 23,100

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Natick, MA

2 Intersection: Route 27 at

At: Rutledge Rd

3 Intersection #: 1

B. Traffic Control Devices:

Approach #:

1. None
2. None
3. None
4. _____

Signals: P = pretimed
A = actuated
(over for signal timing)

C. Speed Limits:

Approach #:

1. _____
2. (not posted)
3. _____
4. _____

D. Volumes (AM/PM)

Appr. #		% Trucks	Peds?
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	B	R	L	
2 Curbing	B	R	L	
3 Parking?	N	*	*	
4 Parking Restricted?	--	--	*	
5 No. of Lanes	1	1	1	
6 Exclusive Lanes?	--	--	--	
7 Lane Widths	>12	>12	12	
8 Bus Stops?	N	N	N	
9 Grade	0%	0%	0%	
10 Crosswalk? (draw)	Y	N	N	
11 Classification*				
12 Jurisdiction				

*angle parking for businesses, right side

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

F. Comments/Observations

_____

_____

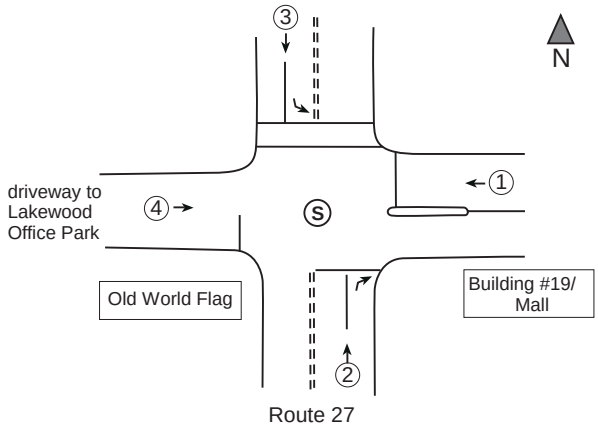
_____

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Natick, MA

2 Intersection: Route 27 at Mall Driveway/

At: business driveway

3 Intersection #: 2

B. Traffic Control Devices:

Approach #:

1. Signal--Actuated
2. Signal
3. Signal--Actuated LT
4. Signal--Actuated

Signals: P = pretimed
A = actuated

(over for signal timing)

C. Speed Limits:

Approach #:

1.
2. (none posted)
3.
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	R	B	B	N
2 Curbing	B	B	B	B
3 Parking?	N	N	N	N
4 Parking Restricted?	--	--	--	--
5 No. of Lanes	2	2	2	1
6 Exclusive Lanes?	**	1R	1L	--
7 Lane Widths	10	12	10	8-10
8 Bus Stops?	N	N	N	N
9 Grade	0%	0%	0%	0%
10 Crosswalk? (draw)	N	N	Y	N
11 Classification*				
12 Jurisdiction				

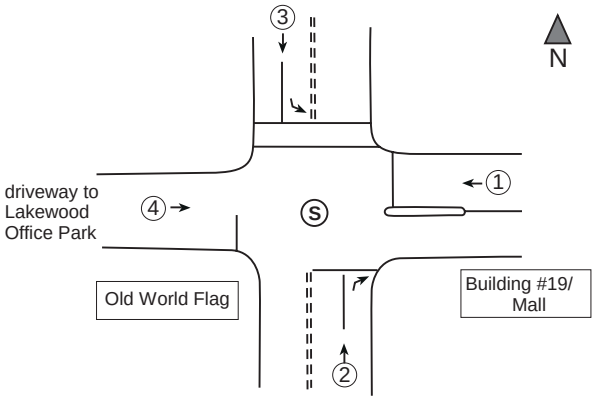
*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

**not striped or marked

F. Comments/Observations

Signal has pedestrian buttons at crosswalk ends.

Driveway to Lakewood Office Park also serves N.E. Home Health--both properties have alternate access at driveway on ramp extension.



Route 27

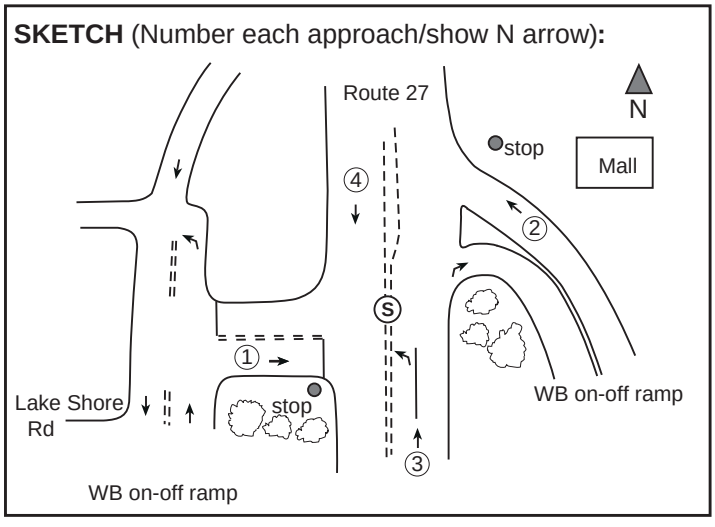
A		B			
G: 7	Y: 3	G: 0	Y: 0	*54 5*	*69 sec*
17 3		*8 3*		*45 5*	*81 sec.*

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Natick, MA

2 Intersection: Rt 27 at Rt 9 on-off ramp termini

At: (north side of Rt 9)

3 Intersection #: 3

B. Traffic Control Devices:

Approach #:

1. Stop sign/flashing red
2. Stop sign
3. Flashing yellow
4. Flashing yellow

Signals: P = pretimed A = actuated (over for signal timing)

C. Speed Limits:

Approach #:

1.
2. (none posted)
3.
4.

D. Volumes (AM/PM)

Appr. #		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	R*	N	N	N
2 Curbing	B	B	B	B
3 Parking?	N	N	N	N
4 Parking Restricted?	--	--	--	--
5 No. of Lanes	1	1	2	1
6 Exclusive Lanes?	--	--	1L	--
7 Lane Widths	12	12+	10-12	15+
8 Bus Stops?	N	N	N	N
9 Grade	0%	0%	-1%	0%
10 Crosswalk? (draw)	N	N	N	N
11 Classification*				
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

F. Comments/Observations

Bridge has narrow 3-lane cross-section, which becomes 1 narrow left, 1through lane

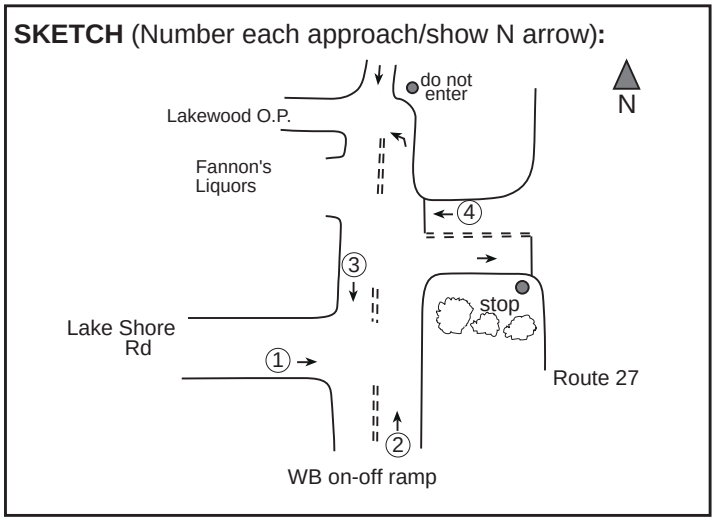
Sight distance restrictions for turning traffic from shrubbery on islands

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Natick, MA

2 Intersection: Rt 9 on-off ramp at Lake Shore

At: (northwest quadrant)

3 Intersection #: 4

B. Traffic Control Devices:

Approach #:

1. None
2. None
3. None
4. None

Signals: P = pretimed A = actuated (over for signal timing)

C. Speed Limits:

Approach #:

1.
2. (none posted)
3.
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	L	L	B	N
2 Curbing	N	B	B	B
3 Parking?	N	N	N	N
4 Parking Restricted?	--	--	--	--
5 No. of Lanes	1	1	1	1
6 Exclusive Lanes?	--	--	--	--
7 Lane Widths	12	12	15+	10-12
8 Bus Stops?	N	N	N	N
9 Grade	0%	0%	0%	0%
10 Crosswalk? (draw)	N	N	N	N
11 Classification*				
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

F. Comments/Observations

Rumble-strip paving separates on-off ramp traffic.

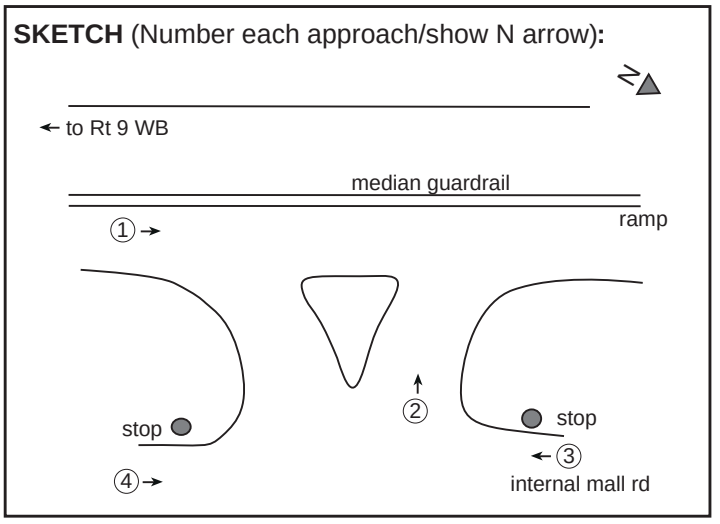
Driveway to Lakewood Office Park also serves N.E. Home Health--both properties have alternate access at "Main Mall driveway" traffic signal.

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Natick, MA

2 Intersection: Rt 9 WB to Rt 27 NB off-ramp

At: Mall driveway to ramp

3 Intersection #: 5

B. Traffic Control Devices:

Approach #:

1. None
2. None
3. Stop sign
4. Stop sign

Signals: P = pretimed
A = actuated

(over for signal timing)

C. Speed Limits:

Approach #:

1.
2. (none posted)
3.
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	N	N	N	N
2 Curbing	B	B	Y	*
3 Parking?	N	N	N	N
4 Parking Restricted?	--	--	--	--
5 No. of Lanes	1	1	1	1
6 Exclusive Lanes?	--	--	--	--
7 Lane Widths	~15	~15	~15	~15
8 Bus Stops?	N	N	N	N
9 Grade	0	0	0	0
10 Crosswalk? (draw)	N	N	N	N
11 Classification*				
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

F. Comments/Observations

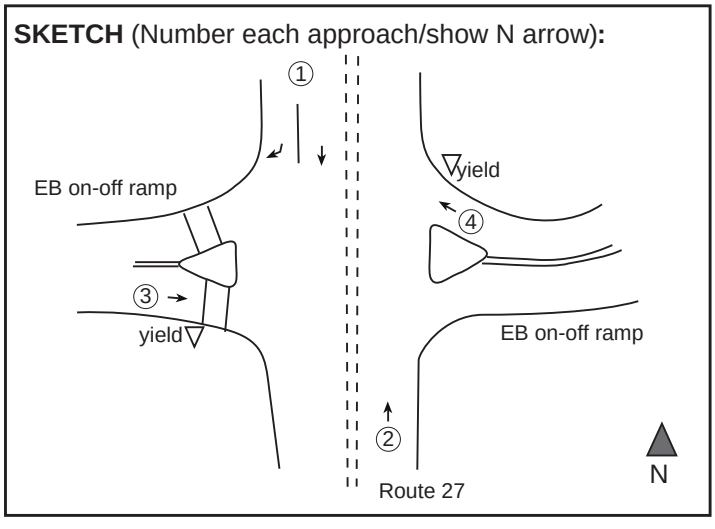
Internal Mall roadway is 2-way.

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Natick, MA

2 Intersection: Rt 27 at Rt 9 on-off ramp termini

At: (south side of Rt 9)

3 Intersection #: 6

B. Traffic Control Devices:

Approach #:

1. None
2. None
3. Yield sign/"No turns"
4. Yield sign

Signals: P = pretimed A = actuated (over for signal timing)

C. Speed Limits:

Approach #:

1.
2. (none posted)
3.
4.

D. Volumes (AM/PM)

Appr. #		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	R only	L only	N	N
2 Curbing	B	B	B	B
3 Parking?	N	N	N	N
4 Parking Restricted?	--	--	--	--
5 No. of Lanes	2	1	1	1
6 Exclusive Lanes?	1R	N	1R	1R
7 Lane Widths	10-12	12+	12+	12+
8 Bus Stops?	N	N	N	N
9 Grade	-.5%	.5%	.5%	.5%
10 Crosswalk? (draw)	N	N	Y	N
11 Classification*			R	R
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

F. Comments/Observations

Bridge has narrow 3-lane cross-section, sidewalk on west side, curbing on east side.

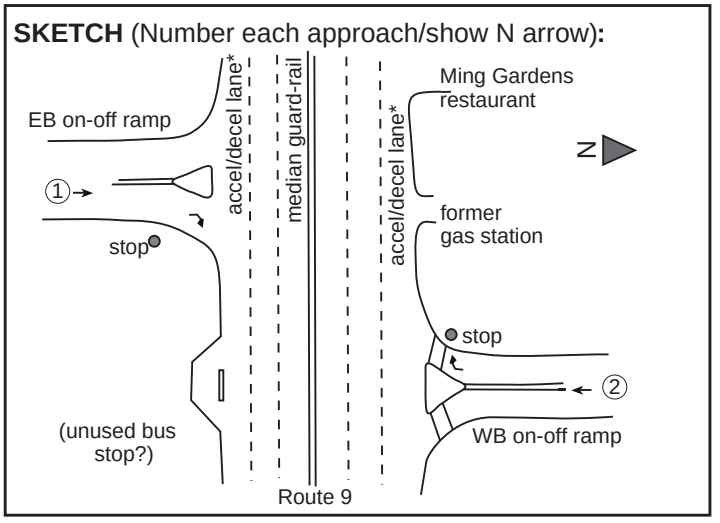
No barrier separation--only paint.except for islands at intersections

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



* becomes narrower shoulder west of here

A. Identification

1 Municipality: Natick, MA

2 Intersection: Rt 9 at Route 27 on-off ramp termini

At: (west of Rt 27 bridge)

3 Intersection #: 7

B. Traffic Control Devices:

Approach #:

1. Stop sign
2. Stop sign
3.
4.

Signals: P = pretimed, A = actuated (over for signal timing)

C. Speed Limits:

Approach #:

1.
2. (none posted)
3.
4.

D. Volumes (AM/PM)

Appr. #		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	N	N**		
2 Curbing	B	B		
3 Parking?	N	N		
4 Parking Restricted?	--	--		
5 No. of Lanes	1	1		
6 Exclusive Lanes?	1R	1R		
7 Lane Widths	10-12	10-12		
8 Bus Stops?	N	N		
9 Grade	0%	0%		
10 Crosswalk? (draw)	N	Y		
11 Classification*	R	R		
12 Jurisdiction				

**narrow sidewalk under bridge, but not on ramp

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

F. Comments/Observations

Ramps have rumble-strip separation and/or guard-rail beyond islands.

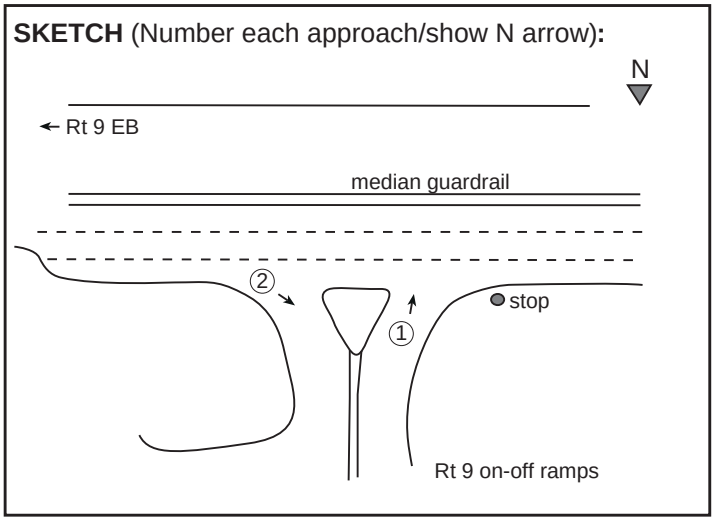
There appears to be an abandoned path leading from the bus pull-out--doesn't go anywhere.

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Natick, MA

2 Intersection: Rt 9 at Rt 27 on-off ramps

At: (east side of bridge)

3 Intersection #: 8

B. Traffic Control Devices:

Approach #:

1. None
2. None
3. Stop sign
4. Stop sign

Signals: P = pretimed
A = actuated

(over for signal timing)

C. Speed Limits:

Approach #:

1.
2. (none posted)
3.
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	N	R*		
2 Curbing	B	B		
3 Parking?	N	N		
4 Parking Restricted?	--	--		
5 No. of Lanes	1	1		
6 Exclusive Lanes?	1R	1R		
7 Lane Widths	~15	~12		
8 Bus Stops?	N	N		
9 Grade	0	0		
10 Crosswalk? (draw)	N	N		
11 Classification*				
12 Jurisdiction				

*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

F. Comments/Observations

* no shoulders on Route 9, but narrow sidewalk

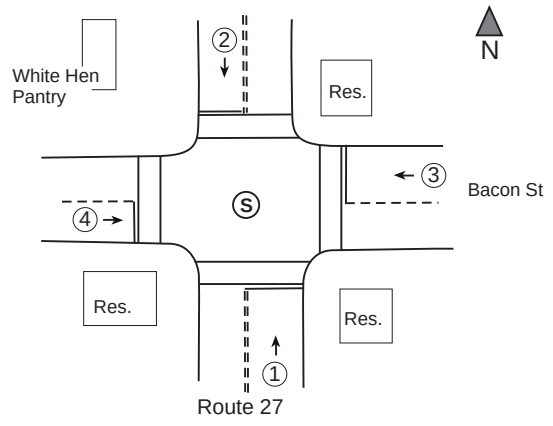
Rt 9 on-ramp has short accel lane which extends under bridge to end of far-side ramps.

CTPS INTERSECTION DATA FORM

DATE: July 30, 1999 **PROJECT:** MetroWest Subregional Area Study:

RECORDER: MPM Route 9/Route 27 Interchange

SKETCH (Number each approach/show N arrow)**:**



A. Identification

1 Municipality: Natick, MA

2 Intersection: Route 27 at

At: Bacon St

3 Intersection #: 9

B. Traffic Control Devices:

Approach #:

1. Signal w/ ped button
2. Signal w/ ped button
3. Signal w/ ped button--A
4. Signal w/ ped button--A

Signals: P = pretimed
A = actuated

(over for signal timing)

C. Speed Limits:

Approach #:

1.
2.
3. 25 mph
4.

D. Volumes (AM/PM)

Appr. #:		% Trucks	Peds?
1.			
2.			
3.			
4.			

E. Approach Characteristics

	APPROACH # 1	2	3	4
1 Sidewalks	B	B	B	B
2 Curbing	B	B	B	B
3 Parking?	N	N	N	N
4 Parking Restricted?	--	--	--	--
5 No. of Lanes	1	1	1	1
6 Exclusive Lanes?	--	--	--	--
7 Lane Widths	12	12	10-11	10-11
8 Bus Stops?	N	N	N	N
9 Grade	0%	0%	0%	0%
10 Crosswalk? (draw)	Y	Y	Y	Y
11 Classification*				
12 Jurisdiction				

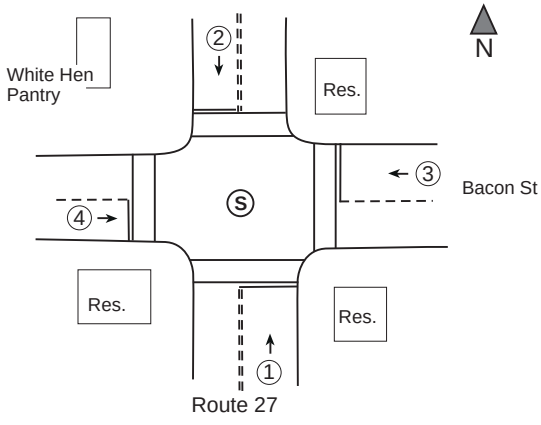
*Class: E = expressway
R = ramp
M = major arterial
A = arterial
C = collector
L = local/res.
D = driveway

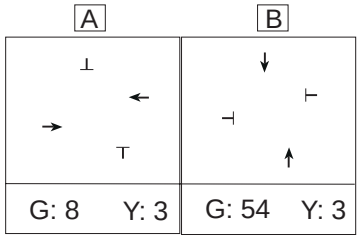
F. Comments/Observations

Signal has pedestrian buttons at crosswalk ends.

Bacon St reportedly used as "cut-through" for traffic avoiding interchange--

reportedly, too much green time to Bacon. No room to bypass lefts on any approach.


N
White Hen
Pantry
Res.
Bacon St
Res.
Res.
Route 27


A
B
G: 8
Y: 3
G: 54
Y: 3

INTERSECTION QUEUES

PROJECT: MetroWest Subregional Study
LOCATION Route 9/Route 27 Interchange
--Route 27 at Bacon St

DATE: August 13/18, 1999
DAY: Friday/Wednesday
BY: MPM

OBSERVED QUEUE LENGTHS PER CYCLE BY APPROACH

AM
8:15-8:45

	Route 27 SB			Route 27 NB			Bacon St WB			Bacon St EB			INT. AVERAGE	
	Left	Thru/Gen	Right	Left	Thru/Gen	Right	Left	Thru/Gen	Right	Left	Thru/Gen	Right	TOTAL	CRITICAL
1		8			3			5			1			
2		1			12			3			1			
3		1			8			4			1			
4		9			6			1			1			
5		0			15			3			1			
6		4			7			3			2			
7		5			2			2			2			
8		2			4			6			1			
9		2			4			5			1			
10		5			3			6			3			
11					6			1			1			
12														
13														
MAX	0	9	0	0	15	0	0	6	0	0	3	0		
AVG	0.0	3.7	0.0	0.0	6.4	0.0	0.0	3.5	0.0	0.0	1.4	0.0	3.7	5.0

PM
5:15-5:45

	Route 27 SB				Route 27 NB				Bacon WB				Bacon EB				INT. AVERAGE	
	Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right		TOTAL	CRITICAL
1		19				4				2				1				
2		32		a		7				6		c		0				
3		26		a		0				4				2				
4		29		a		17		b		2				1				
5		26		a		2				9		c		1				
6		23		a		1				4				1				
7		17				4				3				1				
8		13				16		b		7		c		0				
9		11				7				6		c		1				
10		6				1				4				1				
11		10				0				3								
12						10				7		c						
13						9												
MAX	0	32	0		0	17	0		0	9	0		0	2	0			
AVG	0.0	19.3	0.0		0.0	6.0	0.0		0.0	4.8	0.0		0.0	0.9	0.0		7.7	12.0

/metrowest/rt27/analysis/queues/Rt27-Bacon.xls

a Light turns green after 14th-15th vehicle, but queue builds during "start-up"time.
b Pedestrian button pushed, caused lengthened cycle.
c Most movements are RTOR; longer queues occur because of left-turning vehicles in front.

INTERSECTION QUEUES

PROJECT: MetroWest Subregional Study
LOCATION Route 9/Route 27 Interchange
--Route 27 at Mall Driveway

DATE: August 13/18, 1999
DAY: Friday/Wednesday
BY: MPM

OBSERVED QUEUE LENGTHS PER CYCLE BY APPROACH

AM 7:30-7:45

	Route 27 SB				Route 27 NB				Mall WB							INT. AVERAGE	
	Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right	TOTAL	CRITICAL
1		4		a		10					1						
2		8		a		4					1						
3		2		a		15					3						
4		2		a		9					1						
5		0		a		1					1						
6		1		a		5					2						
7		0		a		9					1						
8		4		a		1					1						
9		2		a		7					3						
10		2		a		1					2						
11																	
12																	
13																	
MAX	0	8	0		0	15	0		0	0	3		0	0	0		
AVG	0.0	2.5	0.0		0.0	6.2	0.0		0.0	0.0	1.6		0.0	0.0	0.0	3.4	3.9

PM 4:30-4:45

	Route 27 SB				Route 27 NB											INT. AVERAGE	
	Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right		Left	Thru/Gen	Right	TOTAL	CRITICAL
1	2	4		a		1	0	b	3		3						
2	1	7		a		7	0	b	4		1						
3	1	4		a		6	0	b	2		4						
4	2	7		a		10	4	b	4		3						
5	3	7		a		18	0	b	5		3						
6	0	2		a		4	0	b	2		4						
7	1	7		a		16	0	b	10		3						
8	1	10		a		13	0	b	2		7						
9	2	7		a		6	0	b	10		1						
10	1	2		a		4	0	b	4		2						
11									9		4						
12																	
13																	
MAX	3	10	0		0	18	4		10	0	7		0	0	0		
AVG	1.4	5.7	0.0		0.0	8.5	0.4		5.0	0.0	3.2		0.0	0.0	0.0	4.0	6.8

/metrowest/rt27/analysis/queues/Rt27-Mall.xls

a advance green (i.e., leading) LT arrow only appears when vehicles don't make it thru on permitted phase.

b all RTOR, except when vehicle in wrong lane by mistake.

MEMORANDUM

TO: **MetroWest Files** **May 7, 1999**

FROM: **Mary P. McShane**

RE: **Tech. Memorandum #4: TMA Employer Data for Framingham Technology Park and 9/90 Area—Comparison with 1990 Census Data**

Analysis of work-related travel behavior is based to a large extent on town- and block-group-based transportation data obtained from the 1990 Census. That data is the only available source of comparable, comprehensive areawide travel behavior. However, questions are frequently raised regarding the continued applicability of these data in the years following the decennial census, particularly for areas undergoing rapid growth or change, such as MetroWest.

The availability of a recent large-sample dataset for a major area of employment concentration within MetroWest—the Framingham Technology Park and "9/90 Crossing" area, provided an opportunity to compare current patterns for the employees of the three companies surveyed, with the patterns observed from the 1990 Census data. The industrial parks in western Framingham are undergoing rapid expansion; "9/90", located south of Route 9, is only beginning to be developed at present—the Staples surveys included employees who were about to move into a new building at 9/90 when the surveys were conducted. The results of the comparison suggest persistent trends but also changes, compared with the Census data results.

1. Introduction

In late 1998, the MetroWest TMA and Transactions surveyed employees of several of the largest firms located in the employment complex at the Framingham Technology Park and 9/90 complex, located north and south of Route 9 in western Framingham, close to the Southborough boundary (see map, **Figure 1**). The purpose of the surveys was to obtain current information about the geographic distribution of employee origins, and about their commuting travel patterns and preferences. The surveys were conducted with the full cooperation and support of the employers, who reviewed the survey forms, distributed and collected the forms, and encouraged employee participation. Hence, the reported response rates were quite high (80 percent or more return rates). A copy of the survey form is attached as **Appendix A.**

The TMA and Transactions coded and tabulated the responses for each employer site, and produced summaries of responses to each question, for use in tailoring packages of ride-sharing measures to offer at each site. The TMA shared with CTPS the information on

employee origins for 3 employers[1], and CTPS provided a GIS-based map of employee origins for the 3 sites, for TMA use.

The employee origin data is of particular interest because it comprises a reasonably large data sample representing one census block group[2], comparable in size to the total number of 1990 Census Journey-to-Work trips reported for that same block group. This block group contains only a few employment sites which are not located within the Technology Park-9/90 complex, notably the Sheraton Tara Hotel, the Framingham Country Club, and the high-rise residential complex at Country Club Lane.

Several key differences between the two datasets should be noted, however. The Census data is obviously older than the TMA data. It is likely to be a smaller, but more representative sample of the different industry types located within the entire block group[3] than is the TMA data[4]. The Census does not collect employee origin-destination data at work sites—only at the home end of the trip. Therefore, Census information about work location is somewhat less reliable than Census information based on home addresses (e.g., auto ownership, trips per household). At the same time, the TMA dataset represents a biased (because voluntary and based on a targeted set of three companies) sample of employment in the block group as a whole.

With these limitations, comparison of the profiles represented by the two datasets still yields observations worth noting. **Appendix B** lists the towns and trip distribution for each dataset.

2. Principal Towns of Origin

First, the 1990 Census Journey-to-Work data for place of employment was tabulated for the block group representing the Technology Park and 9/90 area. Census blocks of origin were aggregated by town. A total of 78 towns of origin, including several in neighboring states were identifiable from this data. By comparison, the TMA data included 221 origin towns. Within the 1990 Census dataset, the most important towns of origin were, in order:

Framingham	451
Marlborough	188
Milford	112
Ashland	105
Boston	82
Holliston	53
Hopkinton	52
	1,043 = 52% of total data (1993 identified trips)

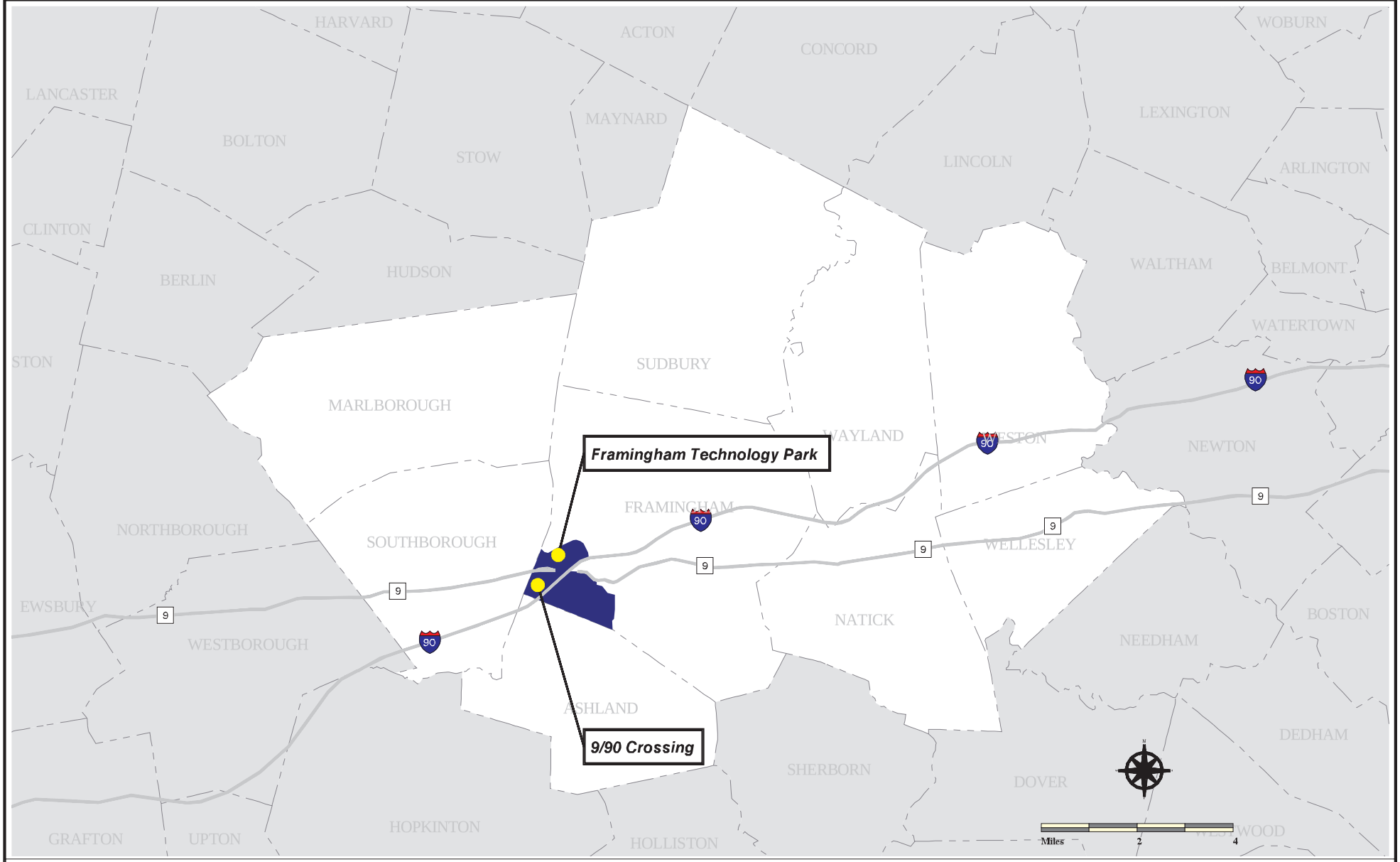
--while within the TMA data from 1998, the most heavily-weighted origins were:

[1] zip codes for 2 employers; towns of origin for a third

[2] County: Middlesex [17] Tract: 3840.00 Block Group: 3.

[3] i.e., including Ryder Trucking, the MetroWest Daily News printers, and other uses which are not predominantly "office" at the Technology Park, plus the nearby service-oriented businesses mentioned in the preceding paragraph.

[4] Largely office/high-tech, plus some skilled manufacturing.



CTPS
MetroWest Subregional Area Study

1990 Census--Block Group 3840.003

Figure 1
Census Block Group/ Location of Employer Surveys

August 10, 2000 pl_mw-20cen.aml

Worcester	112
Framingham	89
Boston	86
Westborough	77
Grafton	69
Marlborough	69
Milford	46
	548 = 31% of total data (1748 identified trips)

The much-higher number of Framingham-based trips in the Census dataset probably reflects, in part, employment at the Sheraton Tara Hotel and the Country Club, not counted in the TMA dataset. But it may also suggest a trend away from Framingham residence among the businesses of the Technology Park and 9/90.

In the 1990 Census data, Worcester represented a comparatively minor origin for trips to the Technology Park destination. The 1998 surveys showed Worcester origins to outnumber Framingham origins in commuting trips to at least the 3 work sites surveyed.

3. Distribution of Towns of Origin

Also noteworthy is the fact that the top seven towns in the rank ordering of origins represented 52 percent of all identifiable origins for work trips in the 1990 Census data, but only 31 percent of all identifiable origins for the TMA survey data. The more recent data appears to represent a more diffuse "commuter-shed", spread out over a wider area and a greater number of towns than the Census data.

Figures 2 and **3** also illustrate this, showing the distribution of all identified origin towns for each dataset. Many of the towns shown as highlighted on the fringes represent only 1 to at most 3 trips. Together, the entire "commuter-shed" area for 1998 would yield a longer average work trip destined for the Technology Park and 9/90 area, compared with the 1990 dataset, as well as a more widely dispersed work force. Such a wide distribution of employees is more difficult to accommodate using ride-sharing modes.

4. Directional Distribution of Origins

Third, overall patterns in terms of directional distribution were examined. In order to do this, the town data were aggregated into radial clusters which represent the different directions of approach to the Technology Park and 9/90 site, as shown on **Figure 4**. The TMA data was similarly aggregated into clusters by approach direction.

Figures 5 and 6 illustrate the comparison for the two datasets. Generally, the relative percentage distributions by direction are fairly similar between the two datasets. No great difference in the share of out-of-state origins was noted, and the shares represented by trips from the area surrounding the Boston Core and the Route 128 corridor (north and south) are quite similar.

The most obvious variation is in the percentage of employees with origins located outside MetroWest: 83 percent of the employees from the TMA dataset reported origins outside the 9 MetroWest communities, compared with 57 percent from the Census dataset. As suggested above, this may be attributable to representation within the Census dataset of employment at businesses such as the hotel and country club—businesses which would be expected to attract mainly local employees. The TMA dataset exhibits different employee attraction characteristics; but these characteristics are expected to represent the majority of new job growth within the Technology Park-9/90 area.

Much of the percentage shift away from MetroWest origins within the TMA dataset is accounted for by the rapidly-growing communities located west and north of Framingham. In particular, the distribution of 1998 TMA data represents a 20 percent shift in concentration of origins away from the 9 MetroWest towns, and toward 4 of the zones identified in **Figure 4**: Zones 10, 11, 12 and 14.

Of these 4 zones, Zone 14, which includes Massachusetts west of Northborough and Westborough, represented only 10 percent of origins in the Census dataset, but 22 percent of origins in the TMA dataset, with a large proportion of this shift attributable to the City of Worcester.

5. Conclusions/Implications

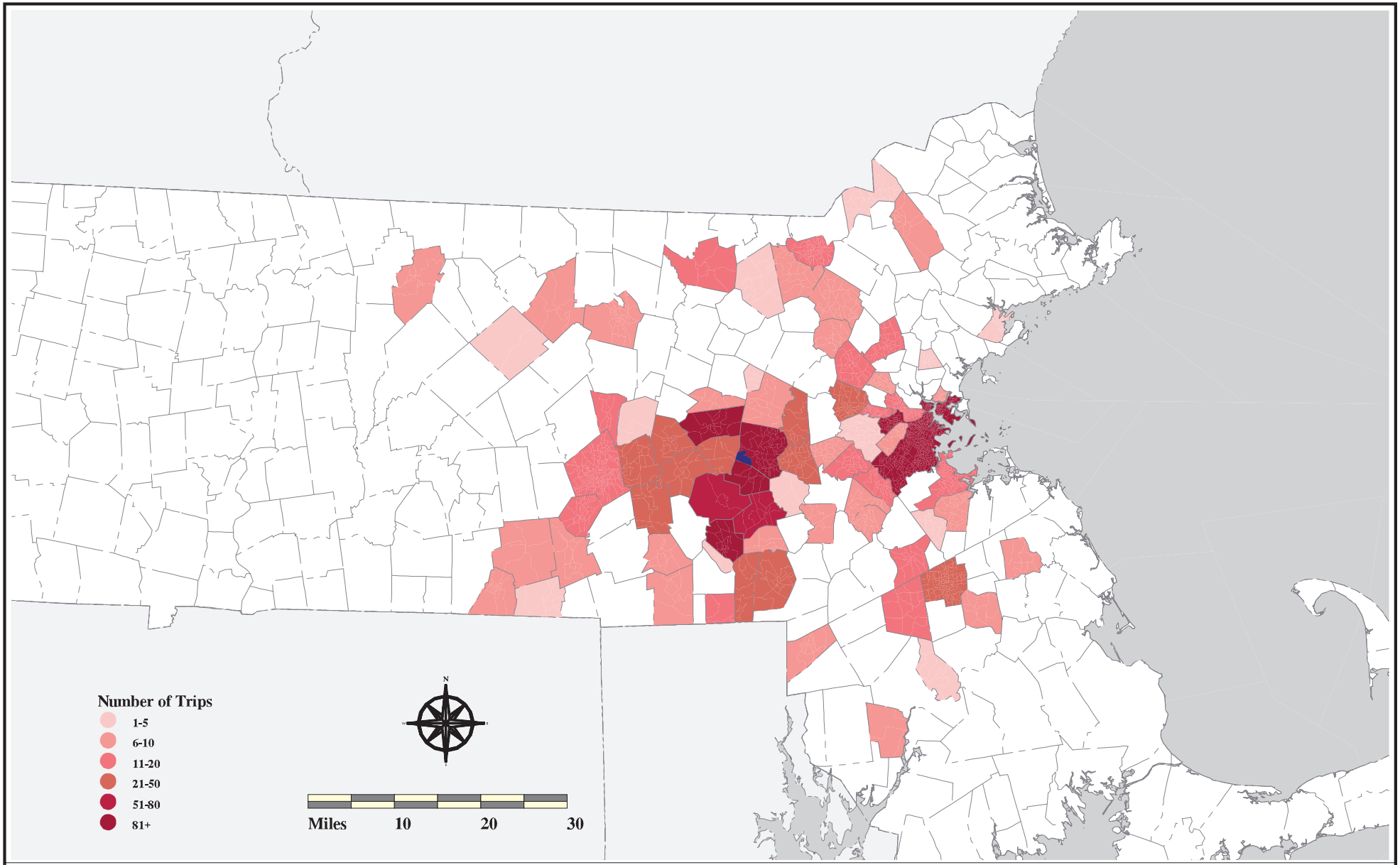
(a) Even in a concentrated area growing as fast as the Technology Park and 9/90 area has been in recent years, inferences about travel drawn from the 1990 Census Journey-to-Work data can still provide useful guidance in general terms.

(b) Some of the differences that were observed between the two datasets probably relates to the nature of the TMA data, representing predominantly office-based high-tech R & D and manufacturing uses to the exclusion of other types of businesses located at the Technology Park and surrounding area. However, the businesses surveyed by the TMA are the types of businesses most likely to represent continued future growth at the Technology Park and 9/90.

(c) The major characteristics of the TMA data, compared with the 1990 Census data for the relevant block group, include:

--reduced concentrations of employee origins away from Framingham and MetroWest;
--increasing importance of towns west and north of Framingham as sources of employment for the Framingham office uses; and
--an overall dispersion of commuter origin points, resulting in longer average trip lengths

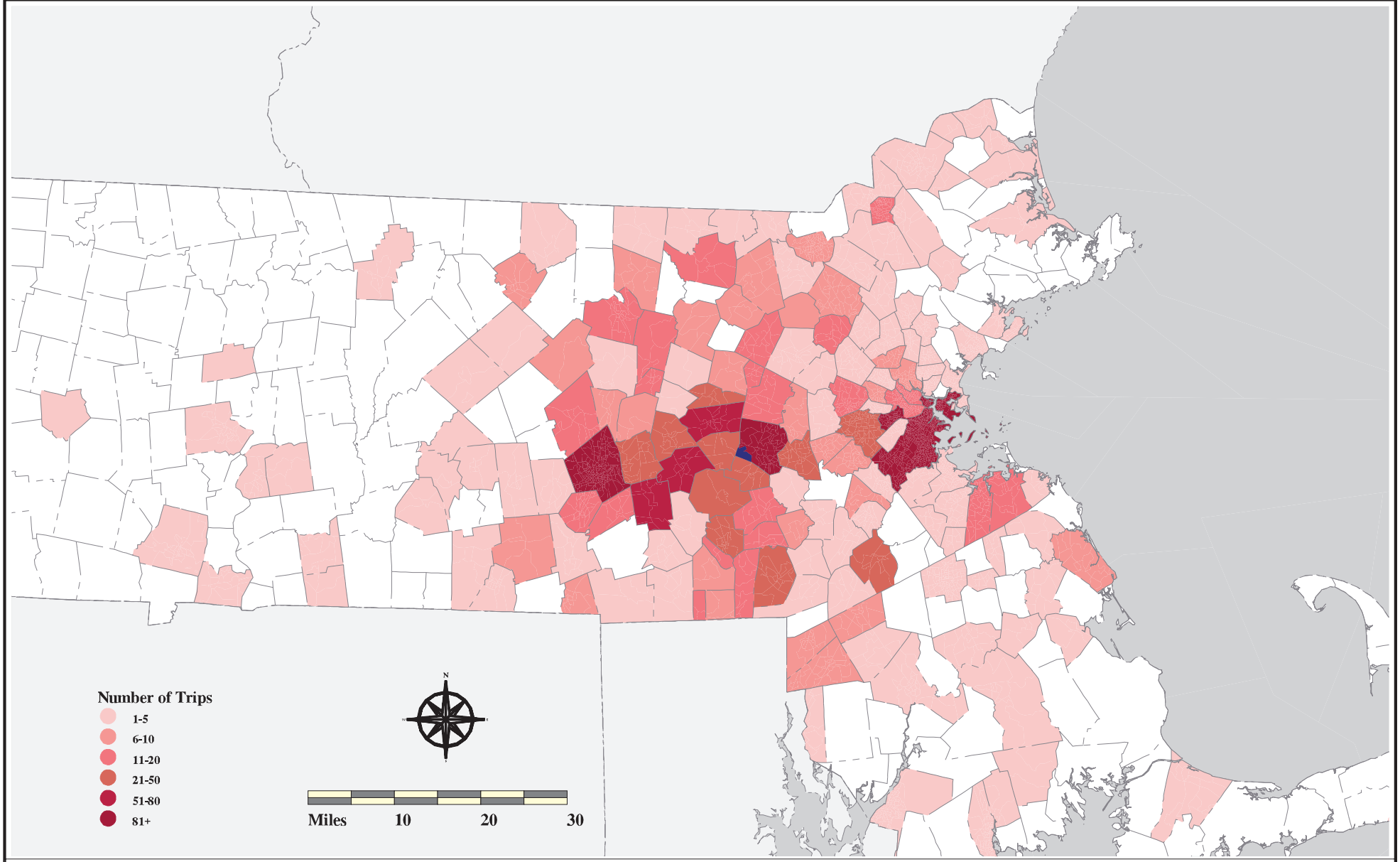
If these represent trends for future growth, as well as explainable differences between the survey populations, they are poor harbingers of success for collective modes of commuting to this site. As employee origins become more dispersed and commuting distances become longer, fixed route transit services become infeasible altogether, and long-term carpools become more difficult to arrange.



CTPS
MetroWest Subregional Area Study

Figure 2
Census Data: Origin Towns for Trips Destined for 9/90

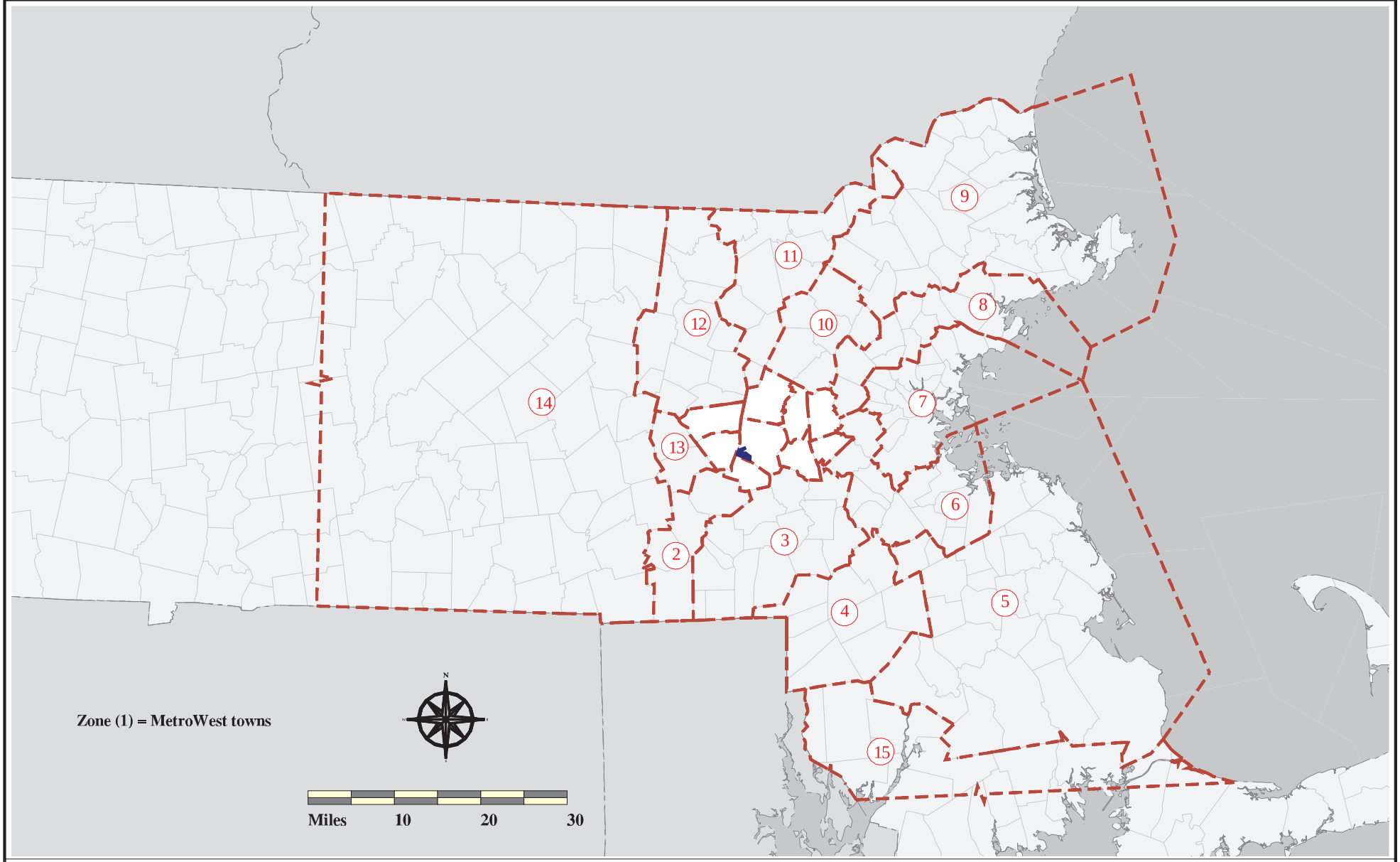
August 10, 2000 pl_mw-18fr1b.aml



CTPS
MetroWest Subregional Area Study

Figure 3
TMA Data: Origin Towns for Employees (Three 9/90 Companies)

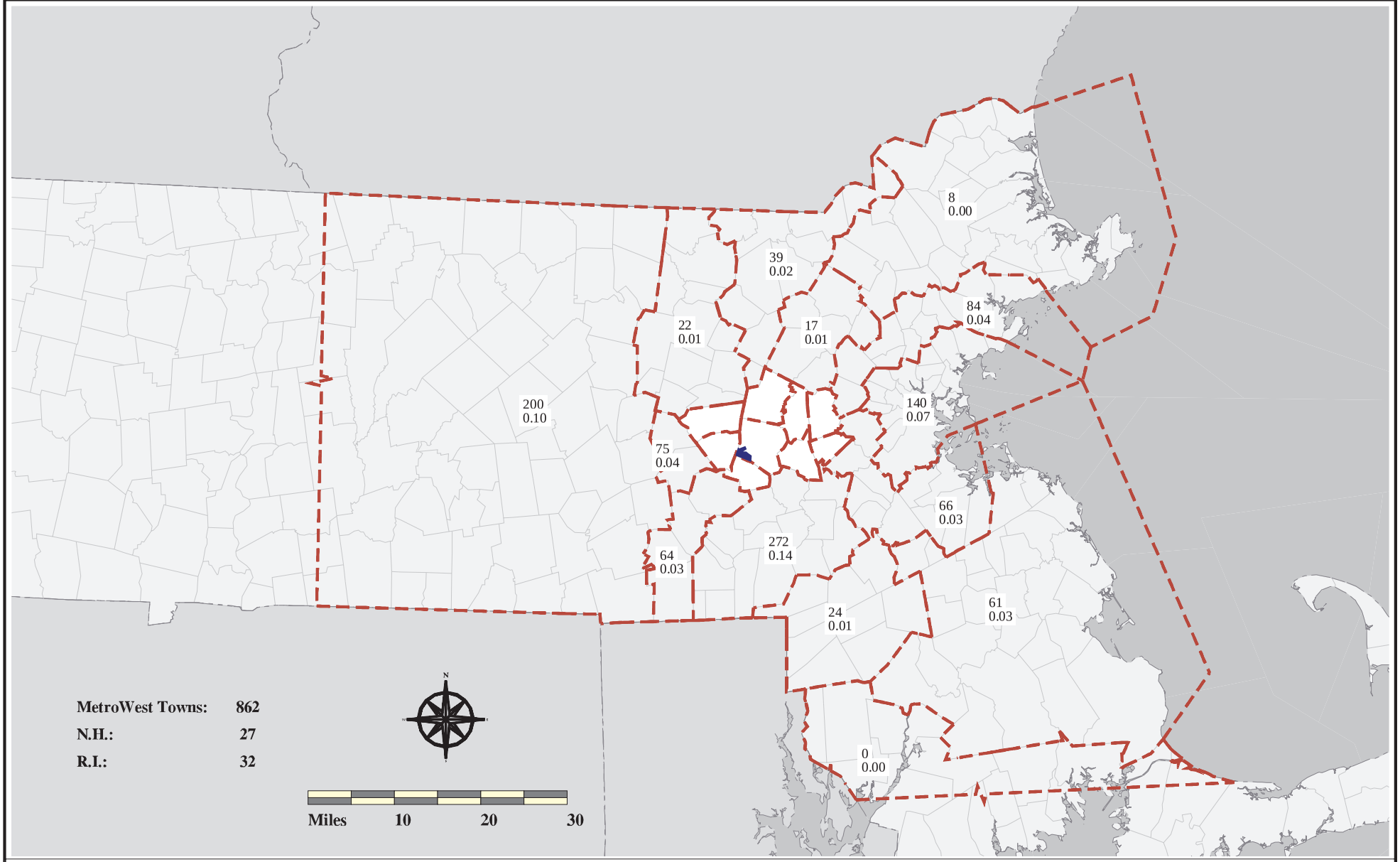
August 10, 2000 pl_mw-18fr6b.aml



CTPS
MetroWest Subregional Area Study

Figure 4
Zones of Aggregation for Work Trip Origins

August 10, 2000 pl_mw-18frab.aml

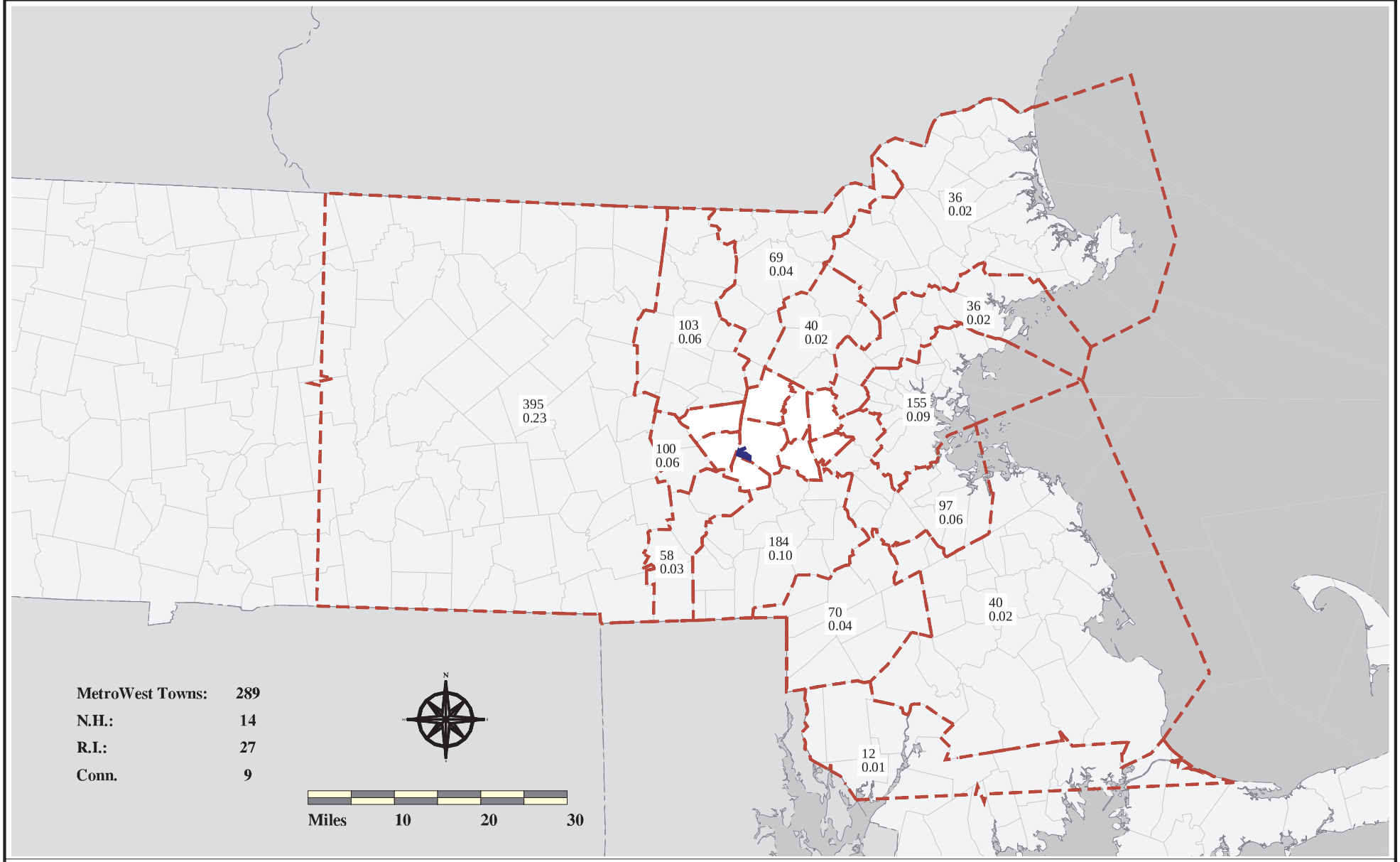


CTPS
MetroWest Subregional Area Study

103 = Number of Trips
0.06 = Fraction of Total

Figure 5
1990 Census: Work Trips with Destinations in 9/90

August 10, 2000 pl_mw-18fr3b.aml



CTPS
MetroWest Subregional Area Study

103 = Number of Trips
0.06 = Fraction of Total

Figure 6
TMA Data: Work Trips with Destinations in 9/90

August 10, 2000 pl_mw-18fr2b.aml

APPENDIX A
TMA Survey Form for Employees
(Not included in Adobe version—see CTPS for copy)

APPENDIX B
Distribution of Origins, Census and TMA Data

1990 Census Journey-To-Work Data:
Towns of Origin for Work Trips to 9-90 Block Group*

Zone**	Town	Trips	Total Trips By Group	Percent of Total Trips
1	Ashland	105		
	Framingham	451		
	Marlborough	188		
	Natick	45		
	Southborough	31		
	Sudbury	7		
	Wayland	28		
	Wellesley	7	862	43.3%
2	Hopkinton	52		
	Northbridge	6		
	Uxbridge	6	64	3.2%
3	Bellingham	43		
	Blackstone	17		
	Franklin	27		
	Holliston	53		
	Hopedale	4		
	Medfield	6		
	Medway	6		
	Milford	112		
	Sherborn	4	272	13.6%
4	Easton	18		
	No Attleborough	6	24	1.2%
5	Brockton	21		
	E.Bridgewater	9		
	Hanover	8		
	Raynham	5		
	Stoughton	18	61	3.1%
6	Braintree	7		
	Dedham	11		
	Needham	17		
	Newton	3		
	Norwood	7		
	Quincy	11		
	Randolph	3		
	Westwood	7	66	3.3%
7	Arlington	8		
	Boston	82		
	Brookline	8		
	Cambridge	18		
	Chelsea	7		
	Melrose	5		
	Watertown	12	140	7.0%

8	Lexington	15		
	Salem	5		
	Waltham	49		
	Woburn	15	84	4.2%
9	No Andover	8	8	0.4%
10	Bedford	10		
	Billerica	7	17	0.9%
11	Chelmsford	8		
	Lowell	17		
	Maynard	5		
	Methuen	4		
	Westford	5	39	2.0%
12	Groton	12		
	Hudson	10	22	1.1%
13	Northborough	29		
	Westborough	46	75	3.8%
14	Athol	6		
	Auburn	19		
	Boylston	5		
	Charlton	8		
	Dighton	7		
	Dudley	5		
	Grafton	32		
	Hubbardston	3		
	Leominster	9		
	Oxford	7		
	Shrewsbury	49		
	Southbridge	7		
	West Boylston	16		
	Westminster	10		
	Worcester	17	200	10.0%
	Hollis, NH	6		
	Hudson, NH	7		
	Pelham, NH	5		
	Londonderry, NH	9	27	1.4%
	RI	32	32	1.6%
	Totaltrips with identifiable origins:		1993	

* Tract/Block Group 3840.003
**as shown on Figure 4

Town-of-Origin Data for 3 9/90 Companies (1998)*
(source: MetroWest TMA/Transactions)

Zone	Town	Three Companies	Group Total	Percent (w/o 'unidentified')
1	Ashland	34		
	Framingham	89		
	Marlborough	69		
	Natick	38		
	Southborough	24		
	Sudbury	14		
	Wayland	10		
	Wellesley	9		
	Weston	2	289	16.5%
2	Hopkinton	26		
	North Uxbridge	2		
	Northbridge	5		
	Upton	2		
	West Upton	15		
	Woodville	3		
	Uxbridge	5	58	3.3%
3	Bellingham	11		
	Blackstone	8		
	Franklin	27		
	Holliston	11		
	Hopedale	11		
	Medfield	5		
	Medway	19		
	Mendon	6		
	Milford	46		
	Millis	8		
	Millville	14		
	Norfolk	4		
	Sheldonville	9		
	Sherborn	4		
	Walpole	1	184	10.5%
4	Attleboro	8		
	Foxboro	3		
	Mansfield	6		
	North Attleboro	9		
	North Easton	1		
	Norton	3		
	Sharon	37		
	South Easton	1		
	Wrentham	2	70	4.0%
5	Bridgewater	1		
	Brockton	3		
	Cohasset	2		
	Green Harbor	1		
	Halifax	1		
	Hingham	11		
	Kingston	1		
	Marshfield	7		
	Middleboro	1		
	Norwell	5		
	Rockland	1		
	South Carver	1		
	Taunton	3		
	Whitman	1		
	Pembroke	1	40	2.3%

6	Braintree	3		
	Chestnut Hill	5		
	Dedham	3		
	Holbrook	2		
	Milton	4		
	Needham	9		
	Newton	35		
	Norwood	5		
	Quincy	2		
	Westwood	8		
	Randolph	1		
	Weymouth	20	97	5.5%
7	Arlington	5		
	Belmont	7		
	Boston	86		
	Cambridge	16		
	Charlestown	1		
	Everett	4		
	Lynn	2		
	Malden	2		
	Medford	6		
	Melrose	3		
	Revere	3		
	Somerville	14		
	Watertown	2		
	Winthrop	2		
	Brookline	2	155	8.9%
8	Lexington	3		
	Marblehead	1		
	Reading	3		
	Stoneham	4		
	Wakefield	2		
	Waltham	13		
	Winchester	7		
	Woburn	2		
	Salem	1	36	2.1%
9	Amesbury	1		
	Andover	4		
	Groveland	2		
	Haverhill	5		
	Lawrence	11		
	Merrimac	1		
	Middleton	1		
	Newburyport	1		
	North Andover	2		
	Pinehurst	1		
	Tewksbury	4		
	Wilmington	1		
	Ipswich	1		
	Newbury	1	36	2.1%
10	Bedford	13		
	Billerica	8		
	Burlington	5		
	Carlisle	6		
	Concord	5		
	Lincoln	3	40	2.3%
11	Acton	19		
	Dunstable	1		
	Littleton	7		
	Lowell	8		
	Maynard	20		
	Tyngsboro	3		
	Westford	6		
	Chelmsford	1		
	North Chelmsford	3		
	Methuen	1	69	3.9%

12	Berlin	3		
	Bolton	2		
	Clinton	14		
	Groton	15		
	Harvard	6		
	Hudson	31		
	Lancaster	11		
	Pepperell	2		
	South Berlin	3		
	South Lancaster	7		
	Stow	9	103	5.9%
13	Northborough	23		
	Westborough	77	100	5.7%
14	Agawam	1		
	Ashburnham	4		
	Auburn	12		
	Barre	1		
	Boylston	7		
	Charlton	8		
	East Douglas	3		
	Fiskdale	5		
	Gardner	6		
	Grafton	69		
	Granby	1		
	Hampden	1		
	Holden	11		
	Hubbardston	5		
	Leicester	1		
	Leominster	16		
	Lunenburg	6		
	Manchaug	1		
	Middlefield	1		
	Millbury	13		
	New Braintree	3		
	North Brookfield	1		
	North Grafton	2		
	North Oxford	10		
	Northampton	1		
	Orange	2		
	Oxford	2		
	Princeton	6		
	Shrewsbury	34		
	South Hadley	1		
	Southbridge	2		
	Spencer	3		
	Sterling	5		
	Sturbridge	5		
	Three Rivers	1		
	Townsend	4		
	Warren	1		
	Webster	8		
	West Boylston	9		
	West Brookfield	2		
	Westfield	1		
	Whately	1		
	Whitinsville	6		
	Wilbraham	1		
	Worcester	112	395	22.6%
15	Acushnet	1		
	Chatham	1		
	Cuttyhunk	1		
	Fall River	1		
	New Bedford	1		
	Pocasset	1		
	Rochester	2		
	Sandwich	1		
	Seekonk	2		
	South Harwich	1	12	0.7%
	Babson Park	3		
	Chartley	3		
	Jefferson	2		

Linwood	1		
Middlesex Essex Gmf	1		
Minot	2		
Wilkinsonville	2	14	0.8%
NH			
Bedford	1		
Hollis	2		
Hudson	2		
Londonderry	1		
Manchester	2		
Nashua	2		
New Boston	1		
Pelham	1		
Salem	1		
Windham	1	14	0.8%
RI			
Barrington	1		
Bradford	1		
Cranston	2		
Cumberland	2		
Esmond	1		
Harrisville	2		
Hope	1		
Narragansett	2		
Pascoag	2		
Providence	4		
Shannock	1		
Tiverton	1		
West Warwick	1		
Woonsocket	4		
Wyoming	1		
North Smithfield	1	27	1.5%
VT			
Amston	1		
North Grosvenordale	1		
Quaker Hill	1		
West Willington	1		
Windsor	1		
Woodstock	4	9	0.5%
unidentified	44		
unidentified CT	6		
unidentified MA	552		
unidentified NH	15		
unidentified RI	12		
unidentified VT	1	630	36.0%
TOTAL	2,378		
TOTAL, less 'unidentified'	1,748		